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The Pistachio Nut—*A New Crop for the Western United States*

Importers claim that each year they could process and sell approximately 15,000 tons of pistachio nuts if they were available. Presently, only a small quantity are produced commercially in California. Experimental work with selected imported varieties, breeding, cultivating, pruning and other horticultural practises at the United States Department of Agriculture's Plant Introduction Station at Chico, California has demonstrated the economic feasibility of this crop for American growers.

W. E. WHITEHOUSE[1]

Introduction

Pistacia is a genus of Anacardiaceous plants comprised of trees and shrubs which exude turpentine or mastic. *Pistacia vera* L. bears the pistachio nut of commerce. The mango, cashew, sumac, poison ivy, poison oak and the ornamental " pepper tree " are also members of the family Anacardiaceae. Several of the *Pistacia* species are used as root stocks upon which to bud or graft the pistachio or as ornamentals. The pistachio is the only commercially acceptable edible nut of some 12 to 15 *Pistacia* species, two American and the rest Old World, all but *P. vera* having drupes with an indehiscent bony endocarp. *P. vera* (Fig. 1) has much larger elongated, keeled fruits with an endocarp that splits into two valves along the keel. The color of its kernel ranges from light yellow to deep green throughout; the quality from a dry, woody, to a rich, oily, nut-like flavor. It is grown on a commercial scale for export principally in Turkey, Iran, Italy, Syria and Afghanistan. Lesser amounts are produced in Lebanon and Pakistan. Scattered small lots of nuts are sometimes exported from nearby countries, but are usually consumed locally.

Only two and one-half to three million pounds of pistachio nuts were imported and consumed annually in the United States from 1931 to 1945. Imports more than doubled from 1946 until 1952. In five of these six years imports ran from five to nine million pounds, Turkey furnishing 8032 tons, Iran, 3630, Afghanistan, 1390, Italy, 1380, and Syria, 958 tons. For the most part these nuts are received unshelled. They reach the consumer as " Red " pistachios after they are roasted and salted, and the shell is colored with a vegetable dye; as " White " pistachios after they are roasted and the shell is coated with a mixture of salt and cornstarch and as " Naturals " when salt only is added after roasting (44).

Although available on our markets as early as 1880, the pistachio nut did not become well known and appreciated until the early 1930's, when the vending machine came into common use as a medium for making peanut, cashew, pistachio and other nuts readily available to the consumer. A decade later, vending machines were accounting for 85 percent of pistachio nut sales. Today these machines, delivering 12 to 15 red colored, salted, unshelled nuts for a nickel, are

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handling one fifth of the nuts sold. More than twice this amount is sold in prepackaged form and the rest is bulk. The shelled nuts go to nut shops, are vacuum packed in cans or are utilized by manufacturers of bakery goods and ice cream. Importers today claim that each year they could process and sell approximately 15,000 tons of these nuts if they were available. Presently in this country, only a small quantity are produced commercially in California.

Americans are eating more nuts today than they ever did. The United States Department of Agriculture (1) estimates that by 1975 the demand for tree nuts will far exceed present supplies. Population increases will assure an annual domestic consumption of over 300 million pounds of shelled nuts. Increased consumption of tree nuts can be expected in those outlets where they are already preferred to peanuts in the baking industry, in home cooking and baking, and in ice cream manufacturing. However, the greatest potential for tree nut consumption will continue to be in confectionary and salting trades, which even now use the bulk of the tree nuts produced.

Origin and Spread

Pistacia vera differs from all other species of *Pistacia* in the large size and spontaneous dehiscence of its fruits. These characters distinguish it not only from all its congeners, but from all the other *Rhoideae* (Sumac Tribe). Nevertheless, in its general habit and particularly in the leaf characters so important as an index to relationship in the *Pistacineae*, *P. vera* is very close to *Pistacia acuminata* Boiss. & Buhse—which has nearly the same range. The leaves of these species are often almost indistinguishable and both are small trees or large shrubs growing in similar situations in central Asia. The aberrance of *P. vera* in fruit characters can be better appreciated when it is remembered that the fruits of all the other species are only 4 to 8 mm. in length and are never dehiscent. Though a leaf impression that seems to belong to the *Section Eupistacia* has been found in the oldest beds known to yield fossil *Pistacineae*, little can be said as to the origin of the very aberrant *P. vera*. It is possible that it arose not in Europe but in Asia and very likely in central Asia where it occurs in a wild state. When the fossil plants of central Asia have been studied as carefully as those of Europe, then we can expect to have some evidence as to the past history of the common pistachio (35).

The pistachio nut was known to the old oriental peoples. The Queen of Sheba considered it a rare delicacy and during her reign over Assyria commandeered the limited crop of nuts for her exclusive use and that of her guests. It is rather generally agreed (26) that the "nuts" of Jacob were pistachio nuts called "batam" by the Arabs and that they were native to Asia and Asia Minor being introduced into Mediterranean Europe at approximately the beginning of the Christian era. Theophrastus, Gallenus and Pliny record it as indigenous to Syria (14). At Ain Teenah, an ancient village 50 kilometers north of Damascus, some 100 trees of an original planting of 25 hectares of the Ballardi variety are still bearing good crops of excellent quality nuts, which are in demand in local markets. Some trees with trunks six feet in diameter (Fig. 2) are found among them and others measure four feet in thickness (37). Trees of varying age are also found in Iran. Bembower (8) reports that some of these growing at Ardekan, Ghazvin, and Damghan are about a hundred years old. A 700-year-old tree (Fig. 3) is still standing in the Kerman area and in fact, pistachio nuts are said to have been grown near Ghazvin some 1500 years ago.

FIG. 1. Fruiting branches of the Sfax pistachio tree at the U. S. Plant Introduction Station, Chico, California. Sfax produces the largest clusters of any known variety but the nuts are small.

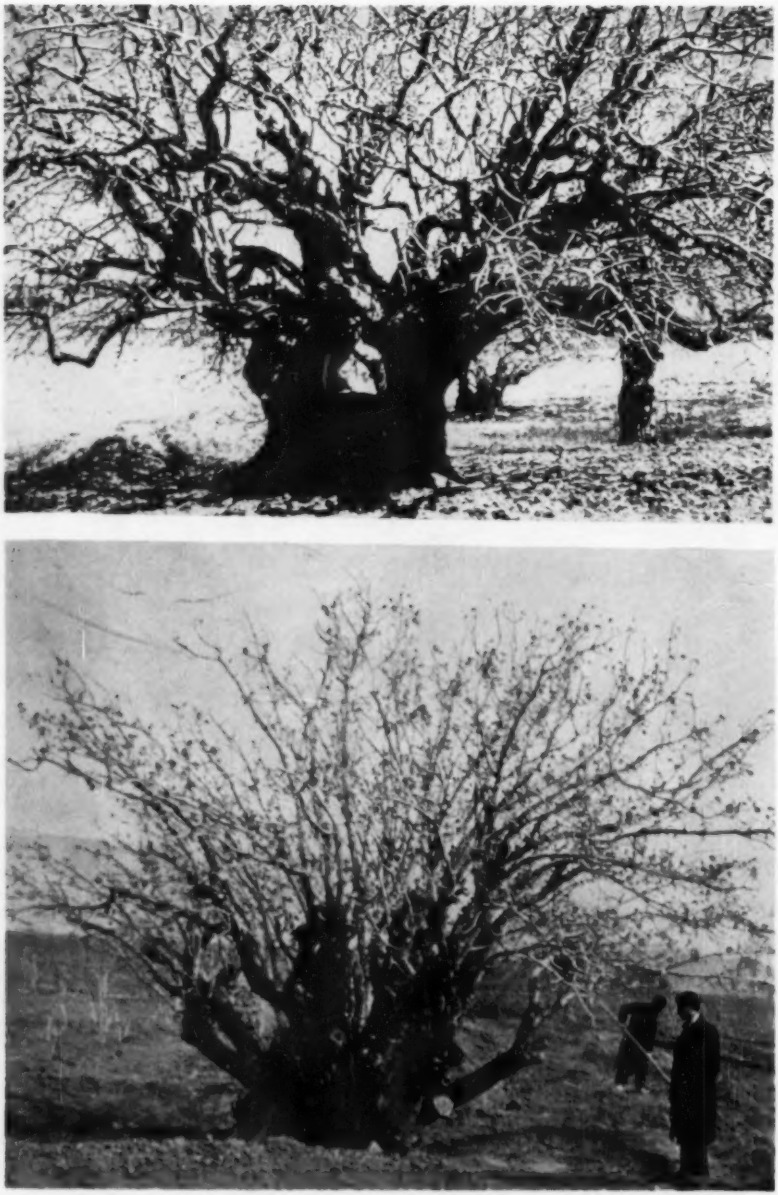

FIG. 2 (Upper). Ancient Ballardi pistachio tree, Ain Teenah, Syria, with trunk diameter of six feet, still produces good crops of nuts. (Photo by Thies)

FIG. 3 (Lower). A 700-year-old pistachio tree near Kerman, Iran. (Photo by Bembower)

Boccone in the year 1697 stated that the pistachio was widely cultivated in the region of Agrigentum, and he discussed the pollination methods used at that time indicating that this nut had been under cultivation for some time. Pliny, moreover, asserted that it was introduced into Italy by Lucio Vitellio towards the year 783. From Rome it probably spread into the other warm parts of Italy. On the other hand, Falci (14) stated that *P. vera* is not indigenous to Sicily and probably was introduced into that region many years after the era of Vitellio, reaching its present importance in recent centuries. He noted the ease of inter-species fertilization and felt certain that erroneous conclusions resulted from studies of specimens not fully corresponding to the true natural species.

Middle Asian *Pistacia vera*

In central Asia (Turkestan), *P. vera* is found growing wild with a few exceptions. It is rather widespread over southern central Asia in the low mountains and foothills in what is considered a semi-desert zone along all mountain chains of the south of central Asia, beginning with the Caspian Sea (Kopet-Dagh mountains) up to Fergana, the region of Tashkent and the mountains of Karatan. East of Karatan in central Tian-Shan, the wild pistachio is found in only three separate small areas. It is not found in the deserts of the Aral-Caspian lowland. Only two small stands are found on the western end of the Kopet-Dagh mountains near the Caspian Sea and near the Iranian frontier (30). One of the largest in Central Asia is the so-called Badkhyz pistachio stands, near Kushka, in the extreme south of Turkmenistan, near the Afghan frontier (34).

These wild pistachio groves extend into northern Afghanistan. Beyond the river Amu-Daria, in the low mountains of the Pamir-Alai, the pistachio is seen everywhere from mountainous Bokhara through the region of Samarkand and the whole of Fergana up to the western Tian-Shan. Large stands are found only in the region adjoining the Amu-Daria, the lower course of the rivers, Kafirnahan, Vakhsha and Kizil-Zu. The distribution of the wild pistachio is sporadic even in its principal area. Historical records tell of pistachios growing in many places where none exist today. The distribution of pistachios has been largely determined by the needs of the local populations who in some instances use the trees as a source of fuel, thus eventually killing them, and heavy pasturing of their cattle in some areas has prevented a natural renewal. The age of the trees range from 6 to 240 years (30).

Aitchison (3) found an abundance of wild pistachio trees growing in northern Afghanistan and observed that during the winter the peculiar gray coloring of the bark of these trees in the distance as seen against the sky resembled smoke. Vavilov and Bukinick (40) observed that the wild fruit trees and shrubs of this country play a by-no-means unimportant part in the nourishment of the population, especially the pistachio whose nuts constitute an important trade for the inhabitants of the provinces of Afghan, Turkestan, Kattakan, Badaksham and Herat. Those sold on the Kandahar bazaar are smaller than the Tunisian Sfax variety and have a high percentage of split shells which are darkly discolored, probably because of improper handling at harvest. The kernels, covered with a deep, dark magenta skin, are pale yellowish green. They are of good quality and often sold mixed with the nuts of the Himalayan edible pine, *Pinus gerardiana* Wall. The pistachio is also found wild in many rocky parts of Lebanon and Palestine (26) and on the Isle of Cyprus (10).

Little was known about the racial diversity of the wild pistachio in 1929 at

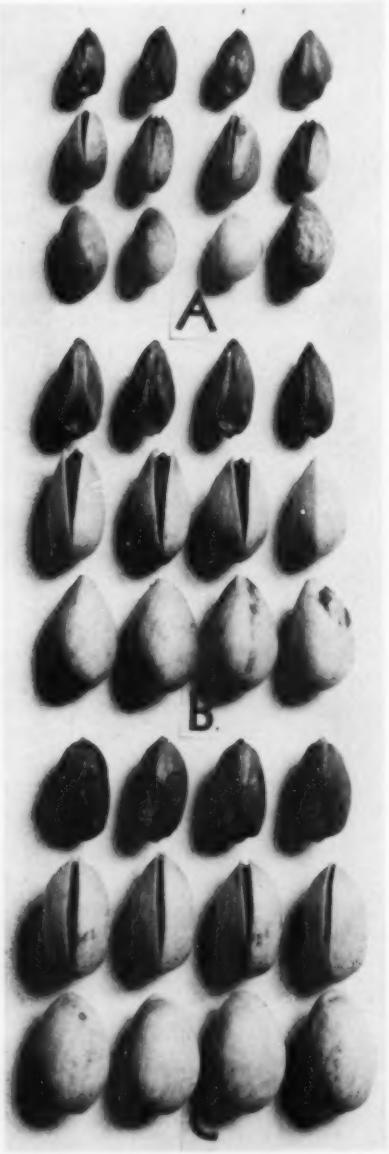

FIG. 4. Pistachio nuts harvested at Chico, California, from three seedlings (A, B, C). Parent tree of seedlings is growing in forests of Turkestan, U.S.S.R.

the time the first surveys of these were made. Popov (30) reported that the wild differed from the cultivated pistachio only in having flowers and fruits that were somewhat smaller. While this may have been mainly the case, evaluation of seedlings grown at the U. S. Department of Agriculture's Plant Introduction Station at Chico, California, which were progeny of some 90 selections of wild Turkestan trees, showed that there was considerable variation in the size of the nuts produced (Fig. 4), some being of acceptable commercial size. Later Russian reports substantiated these evaluations. Trees bearing particularly large nuts have been found in the pistachio forests of Turkmenia (15) and among wild Usbek pistachio trees (39).

The writer, while making a study of the cultivated pistachio orchards of Iran in 1929, noted that the largest and best split nuts came from the villages of Damghan and Rafsenjan. Those from other villages, while commercially acceptable, were somewhat smaller and had fewer split shells. In 1938, Walter Koelz, while on a plant exploration trip for the U. S. Department of Agriculture's Division of Plant Exploration and Introduction, searched for and found a few pistachio nuts of exceptional size among those harvested from the Rafsenjan seedling orchards of Gh. R. Agah, one of Iran's largest growers. Nuts of similar size (Fig. 5) were obtained from this same source in the fall of 1954. There seems to be little doubt that the first commercial plantings in Turkey, Iran, Syria and other countries adjacent to the wild pistachio nut stands were started with seedlings grown from the best of the wild nuts, the growers in the Rafsenjan and Damghan areas being more fortunate in their selections.

World Areas of Production

The majority if not all of the "Pista" nuts consumed in Afghanistan or ex-

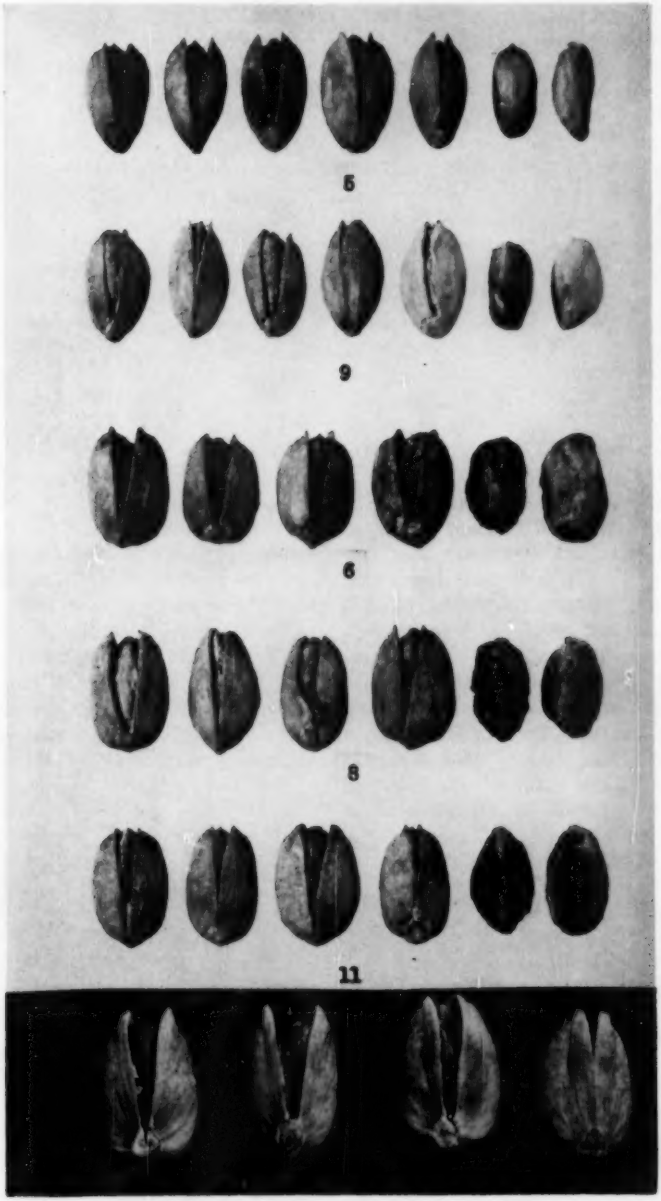

FIG. 5. Nuts and kernels of Trabonella (5), Red Aleppo (9), Damghan (6), Kerman (8) and Lassen (11) varieties. Large nuts (lower row) selected from pistachio crop harvested at Rafsenjan, Iran, in 1954. (Natural size)

ported by that country are harvested from the wild pistachio forests. In India, the crop for the most part is obtained from the wild trees in the hilly tracts of the Northwest Frontier Province and Baluchistan.

In Iran the pistachio tree has been planted commercially for hundreds of years but only in the last forty or fifty years has there been a recognition of the value of the nut as an agricultural crop for export, the tempo of new plantings keeping pace with the rapid increase in American consumption. Today, for example, some 5 million trees are planted in and around Rafsenjan, only ten percent of which are bearing commercial crops of nuts (11). The Damghan Plain is another of the important pistachio growing areas in Iran. In approximately 120 villages scattered through this large fertile valley about 100 miles long and 50 miles wide, pistachio nuts have long been a most important agricultural cash crop. Damghan itself has been an important city and center of a vast agricultural area as well as a trade route between China and Europe for many years. Archeological ruins reveal that it was a great city as far back as 3500 B.C. and remained as such until 500 A.D. During parts of this period, this population is estimated to have reached as many as 1,000,000 people (32).

In 1954, Iran harvested 9000 tons of nuts, 4000 tons from the half million bearing trees at Rafsenjan; 2000 tons from one-half that number of trees in the nearby Kerman and Sirjan areas; 2500 tons from Ghazvin and the remainder from Damghan, Shiraz and Meshed (12).

Syria and Palestine have long been famous for their pistachio trees and the town of Tavna in the Aleppo region is thought to have its name derived from the abundance of pistachio nuts grown there. Damascus is noted for the quality of its pistachio nuts. The growing of this nut in Palestine has declined until today only small plantings are to be found (26).

Pistachio culture in Turkey is centered in the dry, barren foothills and lower ranges of southeastern and western Turkey (Fig. 6). The principal producers are the valeyets of Gaziantep and Urfa but there is some cultivation of the crop in eastern Seyhan, southern Maras, Malatya, Diyarbakir, northern Mardin and Siirt. It is estimated that a million or more trees are growing in each of the principal pistachio areas, a number of which are over a hundred years old and bearing crops of 150 pounds each. Wild trees, principally those of *P. terebinthus* L. and *P. khinjuk* Stocks, are found generally throughout this region (Fig. 7) as far west as Mugla. These are low-growing, shrubby plants and compose a considerable portion of the scrubby growth which covers the barren, rocky hills of some areas in Gaziantep, Maras and Urfa (16).

The Turkish government, recognizing the agricultural importance of its pistachio nut orchards, has a Horticultural Experiment Station at Gaziantep devoted entirely to studies designed for the improvement of this nut. Turkey today is the world's largest exporter of pistachio nuts to the United States. As the more recent plantings in Iran and Turkey reach bearing age, these two countries will be supplying the bulk of the nuts exported to American and European markets.

In Italy the nut is grown in the Catania and Girgenti provinces. Falci (14) conducted his study of the pistachio on the plantation of his godfather, Giocomo Mario Spoto of Catolica, in the province of Girgenti and described it as one of the most beautiful and prosperous plantations of pistachio he had ever seen. There are large plantings at Carini, twenty miles from Palermo. Sicilian nuts are reported to be larger and greener and are particularly esteemed by con-

FIG. 6 (Upper). Olive and pistachio orchards border the forests of *Pistacia terebinthus* and *P. khinjuk* near Gaziantep, Turkey.

FIG. 7. (Lower) *Pistacia terebinthus* and *P. khinjuk* grow wild in the dry hills north of Gaziantep, Turkey.

sumers. Gallesio in 1831 described the Sicilian pistachio as best known and of best quality. Bronte exports more nuts than other Sicilian provinces.

The pistachio nuts of Tunisia, N. Africa, are smaller than those of Sicily and have less commercial value, but are equally appreciated. Gallesio, commenting on the pistachio nuts grown in Tunisia, describes them as smaller than Sicilian nuts but rivaling the Sicilian in good green color of kernels. Their lack of uniformity in shape, flavor, and size, in contrast to those harvested from known varieties in Sicily, is attributed to their seedling origin. In recent years there has been a renewed interest in planting pistachio nut trees in Tunisia and other North African countries where it grows well. There are also orchards near the mouth of the Rhone valley in France and in Australia (8).

Varieties

Pistachio nuts are classified in the trade according to the country of origin, i.e., Afghan, Iranian, Sicilian, Syrian, and Turkish. The Iranian pistachios are considered dry and have a light yellow kernel color. The larger sizes lack somewhat the rich oily nut-like flavor of the Sicilian, Syrian and Turkish nuts, which are preferred because, on the whole, they are considered better tasting and their kernels are almost green throughout. One large New York importer describes Turkish and Syrian pistachios as green to light green in color and of high quality. Italian nuts sell at a premium because of the dark green color of their kernels and the smaller Afghanistan nuts, also preferred for the deep green color of their kernels, are in demand by the ice cream and pastry industries.

Importers purchase their nuts in the "natural state", grading, processing, and selling them under their own brand names. Iranian 8 Star Colossal, Iranian 7 Star Giants, Italian 5 Star Extra Jumbo, Turkish 4 Star Jumbo and Afghan 3 Star Buds are the brand names of one New York firm; Iranian Giants (Monarch), Iranian Midgets (Tulip), Sicilian (Royal) and Syrian (Crown) are the brands of another.

Bembower (8) reports that during the last 25 years, Iranian growers in the Rafsenjan area under the leadership of Gh. R. Agah have been selecting and naming some of the best of their seedlings. Of the thirteen varieties tested the following appear to be the most promising: Ibrahimi, a good quality nut named after one of the growers; Owhadi, bearing large bunches of green-hulled, high splitting, fair-sized, good quality nuts; Safeed, named for the light-colored shell and hull of its nuts; Shasti, a variety grown in that area for a long time, and Wahedi, which bears the largest nuts of any local variety. It is interesting to note that the Wahedi is always a lighter bearer than the others, provided they escape injury from late spring frosts. Lack of adequate pollination may be the cause of light bearing, and the size of the nuts probably would be reduced if the tree produced a good crop. The varieties named are being planted in Damghan and other important pistachio growing areas in Iran.

Turkey has a number of named varieties, the two most commonly planted being the Uzun and Kirmizi. Nearly half of the crop harvested in some areas consists of nuts of these two varieties. The nut of the Uzun variety is long (24 to 26 mm.) and plump, some of the nuts being half as wide as they are long. Kirmizi is a red-hulled, thin-shelled, free-splitting, green-kerneled nut of medium size, containing ten percent more protein than the Turkish Red Aleppo variety. Kernels of the latter variety were found to contain 20.3 percent protein and 65.47 percent oil (9). The origin of the Red Aleppo variety grown in California is not too clear. In 1906 it was presented to the Office of Seed and Plant Introduction by Rev. A.

Fuller, under the name Large Red Aleppo, for trial at Chico. Presumably, it is a seedling of the Turkish Red Aleppo variety, the hulls of which are so characteristically red. It was grown and selected at Saratoga, California by Rev. Fuller upon his return from Turkey, where he was stationed for a number of years.

In Syria, there are distinct varieties: Alemi, Obiad, Mirhavy, Achoury, Ayimi, El Bataury, Aintab, Ashoori, for example.

The Trabonella and Bronte varieties introduced from Sicily in the early 1900's came from the Duke of Bronte's estate. Sanguigna, Girasola, Girasola Cappuccia, Bianca Giardino, Bianca Regina, Rappa di Sessa, Minnullina, and the three Gialla strains are also well-known Sicilian varieties.

The first varieties tested at the Chico Station during the period 1902 to 1930 were Buenzle, Bronte, Minasian, Red Aleppo, Sfax and Trabonella. They failed to measure up to the requirements for a good commercial pistachio nut variety for this country, where higher production costs emphasize the need for high-yielding, high-shell splitting, large-kerneled types. In some years the crop on some varieties has been seriously reduced by late frost injury to flower clusters. Of the earlier varieties tested at Chico, the Red Aleppo and Trabonella have been the most promising from the standpoint of quality and green kernel color. Yields of these varieties over a period of years, while fairly good, have not been sufficient to recommend them for commercial planting nor has splitting of their shells been great enough.

The program for the development of better varieties, which became one of the Office of Foreign Plant Introduction's objectives in 1929, has yielded several seedling selections of promise. Three of these, Kerman, Damghan and Lassen (Fig. 5), have been undergoing an evaluation since 1940 and have shown sufficient promise, both from the standpoint of blooming late enough to escape spring frosts and that of tree performance, to recommend extending their tests into other areas of California suitable to the growth of the nut. All three bear nuts that, as a rule, are larger in size and higher in shell-splitting than any of the other varieties tested thus far.

FIG. 8. An occasional seedling, as illustrated by the Kerman variety, produces some nuts, the bony endocarp of which consists of two pieces: the smaller, elliptical piece covering an opening on the inner side of the nut. The large piece of shell normally splits nearly to the base and the smaller piece, when present, sometimes splits in the same fashion.

In some years a portion of the Kerman nuts have an underdeveloped second shell section, a sort of flap (Fig. 8), which commonly falls off during harvest or processing, exposing the kernel more than is normally the case with nuts having only one shell. Processors are of the opinion that this characteristic does not lessen this variety's acceptability as a commercial nut for their unshelled, salted nut trade. Lassen and Damghan nuts have not exhibited this trait.

Propagation

Establishment of a seedling pistachio orchard with nuts collected in areas where species males other than *P. vera* act as pollenizers is not practical. Since most *Pistacia* species except *Pistacia*

lenticus L. can be easily reproduced by budding, the seedlings derived from such a source are utilized as rootstocks upon which to bud the better varieties.

References to methods of propagating the pistachio tree found in the literature on its culture are often sketchy and conflicting, but it is apparent that budding is more widely practiced than grafting. *P. vera* cuttings do not form roots readily as do those of many other plant species. In grafting older trees, cutting back of large limbs exposes areas which heal slowly and which must be protected against decay-causing organisms. At the Nikita Botanical Garden in Crimea, U.S.S.R., the best results have been attained by bark grafting in April (1). In India, grafting and budding are done late in May. In Iran, ring budding has been practiced in the nursery and grafting on the older trees. In the early work at Chico, grafting proved somewhat unsuccessful and great care was necessary in placing the scions. The bark graft was preferred.

In California (42), propagation of the pistachio nut is usually done by T-budding, placing two buds on each stock to insure a set of at least one. Zhigarevitch (45) obtained a better set of buds when wood was removed from the bud before placing it on the stock. In the California work no improvement in bud-take resulted from removal of wood. Budding may be carried out over a considerable period, but if it is started before mid-April, when sap flow is apt to be excessive, a light set of buds may be expected. A marked improvement in bud-take occurs as the time of budding is extended through the summer and fall until the bark on the rootstocks starts tightening. Buds of both female and male *P. vera* varieties are rather large and require a seedling of fair-sized diameter to accommodate them. It is seldom that all rootstock seedlings are of sufficient size to bud during the first season's growth. One and one-half inches of bark (Fig. 9) are cut with the bud, the longer shield favoring maximum set.

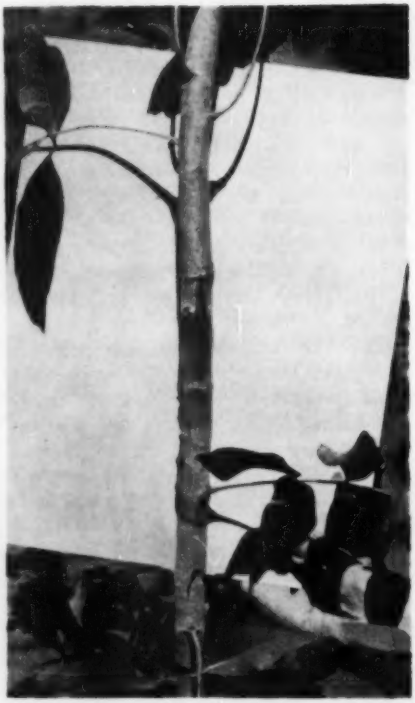

FIG. 9. Newly placed pistachio bud showing long bud shield and T-cut.

Seeds of *Pistacia* species are collected in the fall, cleaned and stored dry at approximately 70° F. until time to plant. Removal of the soft, external epicarp or hull is accomplished by soaking the fruits in water for a few hours, then rubbing and washing them on a coarse screen. This soft portion must be removed before planting since it acts as a germination inhibitor. The cleaned seeds should be dried rapidly to avoid danger of molding, preferably at temperatures below 100° F.

Seed can be planted in the nursery row from late fall to early spring. Seeds of

Pistacia altantica Desf. can be planted without any pregermination treatment, but soaking in water for a few hours sometimes aids germination. This pregermination soaking is usually more beneficial if planting is delayed beyond late March. Seeds of *P. terebinthus* tend to be more variable than those of *P. atlantica* in their germination response for reasons not yet explainable. Washing the seeds thoroughly in running water will generally remove and control excessive mold that may form on them during pregermination treatment.

It is important that the soil be kept damp and free from crusting throughout the germination period. Mulching the seed row is both desirable and beneficial. Almost any material that provides cover, such as sawdust, leaf-mold, sand, black

FIG. 10. Forty-five-year-old orchard of the Red Aleppo pistachio variety growing on *Pistacia atlantica* rootstocks at Elk Grove, California.

They do not require pregermination treatment if planted during the fall and winter. If planting is delayed until late March or April a more favorable response is usually obtained by soaking in water several hours, draining and holding them damp for two to three weeks at room temperature (about 70° F.) or until they begin to show signs of germination. Dampness can be retained by holding the seeds in some non-porous container, such as a polyethylene bag. polyethylene covering or even newspapers, can be used. Should either of the last two materials be used, care must be taken to make sure that an opening to the sun is provided as soon as the young seedlings appear above ground.

For those who may wish to grow *P. vera* seedlings to the fruiting stage, a speedy and effective method is to soak the seed in water in a refrigerator at approximately 40° F. for two weeks prior to planting. Approximately half of

the resultant seedlings will be females. *Pistacia chinensis* Bunge seeds, like those of *P. atlantica*, can be sown without any pregermination treatment other than removal of the hull and a short soaking in water.

With early planting of seed, good care in watering and an ample supply of nutrients throughout the summer, part or all of the more vigorous pistachio seedlings may reach budding size by fall. The first two or three months are critical in the life of the seedlings and, though a good moisture supply is essential at all times, care must be exercised to make sure that they are not overwatered lest damping-off and wet feet problems develop. Should there be sudden blackening and death of some seedlings from injury in the crown or roots, water must be withheld for awhile, allowing the surface soil to dry and aerate. Before the watering is resumed in such instances, it would be advisable to mound the soil beside each row so that free water can be kept away from the crown of the young plants. In the early stages thrips sometimes become quite active around the terminal growth of each seedling.

A Description of Eight Pistachio Nut Rootstocks

In addition to *Pistacia vera*, at least seven other species of *Pistacia*, even though of no interest for their fruits, have been used as rootstocks upon which to bud or graft the pistachio nut. The following species descriptions and notes on the distribution of each are presented as an introduction to a discussion of pistachio nut rootstocks.

FIG. 11 (Left). Good stock-scion compatibility of thirty-five-year-old Red Aleppo scions bark-grafted on *Pistacia atlantica* (arrow).

FIG. 12 (Right). A forty-year-old *Pistacia atlantica* tree at Leeds, Utah—an excellent shade tree for the hot, arid south-western United States.

1. *Pistacia vera* L. is a small tree attaining a height up to 30 ft. (Fig. 10), with spreading branches. Leaves pinnate, at first tomentose, then glabrous, somewhat coriaceous, borne on angular petioles; leaflets 1 to 5 pairs, ovate obtuse, nearly sessile, ovoid, oblong, pedicelled, reddish and wrinkled (7).

2. *Pistacia atlantica* Desf. attains a height of 40–50 feet and a diameter of 4½ feet in northern Sahara, where it is found. Leaves deciduous, odd-pinnate; leaflets 7 to 11, alternate, lanceolate, ob-

tuse, glabrous and sessile with narrow winged petioles. Pistillate flowers are borne in loose axillary panicles and staminate flowers are axillary and more compact. The heartwood of the tree is brown, resembling that of walnut (7). The trees of this species are found in sandy, uncultivated fields not far from the city of Gafsa, Libya, and in the mountainous districts of the Mediterranean region, Algiers and the Canary Islands (21). This species is sometimes referred to as the Algerian, or North African terebinth.

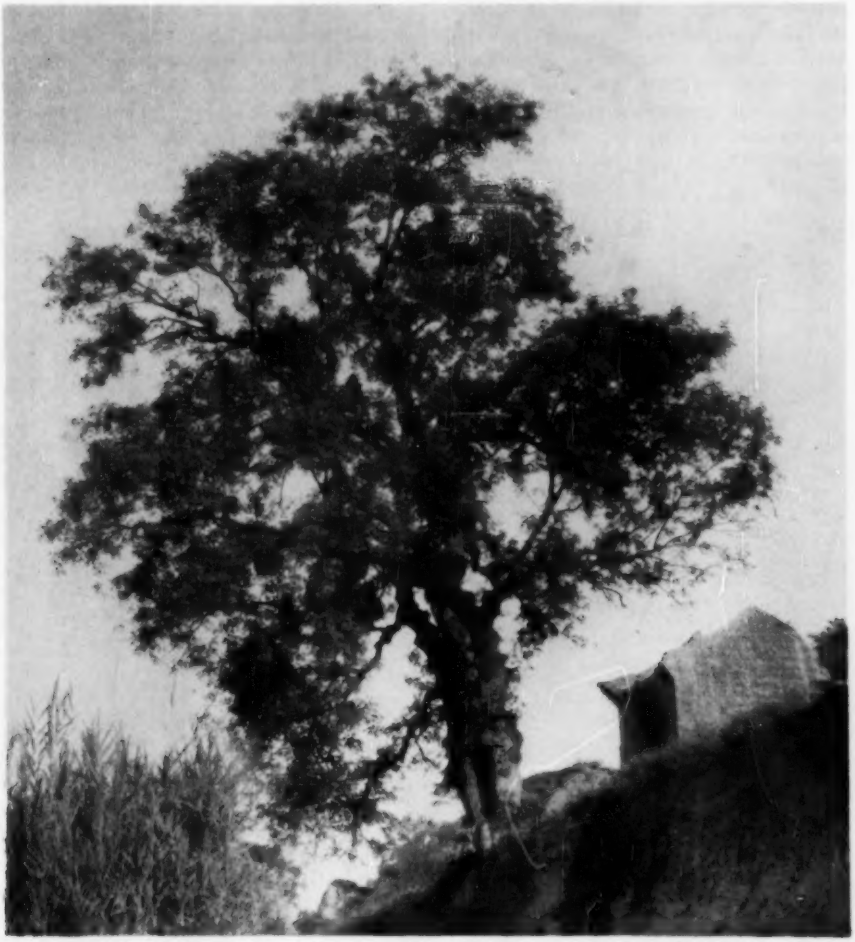

FIG. 13. *Pistacia chinensis* tree on the side of an old road near Shensi, China.

Pistacia atlantica was among those pistachio rootstocks recommended to California growers some 45 years ago. Trabonella and Red Aleppo grafted on

Atlantica seedlings at that time have made a good growth (Fig. 11) and show no evidence of stock-scion incompatibility. In California and Utah, *P. atlantica* grows well on unirrigated soils varying in texture from a light gravelly sand to a heavy clay (Fig. 12), attaining a height of 50 feet. On a gravelly hillside site in central California, Atlantica seedlings at the end of 8 years had made twice the growth of those of Chinensis.

Pistachio nut varieties propagated on *P. chinensis* have been shortlived as compared to those on other species stocks. Extreme scion-rootstock incompatibility is observable at the end of the first season's growth in the nursery, and later stock-scion incompatibility, similar to that on *P. terebinthus*, occurs (Fig. 18).

FIG. 14. Male tree of *Pistacia integerrima* at Chico, California.

3. *Pistacia chinensis* Bunge. A tree with large, spreading branches and heavy trunk often reaching a height of 60 feet (Fig. 13). Leaves are deciduous, odd-pinnate; leaflets 5 to 7 pairs, short petiolulate, lanceolate, long-pointed. The inflorescence is a branched panicle. The fruit is an obovoid-rotundate drupe, compressed, about ¼ inch long and broad, scarlet, turning purplish (7). Although this species occurs in abundance over most of China (Fig. 13), being native to 13 of the 18 provinces, and extends almost to the borders on all sides, it has not been found outside of China; thus the species name is quite appropriate. It often occurs in small groves with tombs beneath its shade.

Although of little or no value as a rootstock for the pistachio, *P. chinensis* makes an excellent ornamental shade tree, particularly for California and other states having an environment favorable to the development of the brilliant fall coloring of its leaves and fruits. The trees tend to develop weak crotches and require training during their formative years if limb breakage is to be avoided when the trees reach mature size.

4. *Pistacia integerrima* Stewart. A medium to large tree, sometimes reach-

ing 40 or more feet in height and a trunk diameter of 2½ to 3 feet (Fig. 14). Leaves aromatic, even- or odd-pinnate, and finely pubescent when young; leaflets 4 to 5 pairs, usually opposite, lanceolate from an oblique base with short petiolules, long-pointed. Fruit a drupe, broader than long, ¼ inch in diameter. *P. integerrima* grows on the warm slopes of the Himalayan mountains usually at an altitude of from 1200 to 3000 feet. It is little known in cultivation (7).

5. *Pistacia khinjuk* Stocks. A smooth-barked shrub. Leaves odd-pinnate, at first velvety pubescent; leaflets 1 or 2 pairs, oblique, broadly ovate or oblong. Nuts small, obovate, compressed. It occurs not uncommonly in the Steppe regions of western Asia, east to the western part of the Himalayas especially in Afghanistan and the adjoining regions to the north. In the U.S.S.R. botanists report that it grows wild on very clay-like soils, indicating that, like *P. mutica* Fisch. & Mey. and *P. terebinthus*, it is capable of growing under a wide range of conditions. It is also reported as native to Turkey. This little known species, like *P. mutica*, more nearly resembles *P. vera* in most of its vegetative characters.

FIG. 15. Seedling tree of *Pistacia lentiscus* at Chico, California.

6. *Pistacia lentiscus* L. is a bushy or shrubby tree up to 12 or 15 feet tall (Fig. 15). Leaves evergreen, even-pinnate or sometimes odd-pinnate, petiole winged; leaflets of 2 to 5 pairs, leathery, elliptic, oblong or obovate, obtuse, mucronulate. The axillary panicles are small and stiff. Fruit small, orbicular, slightly annulate,

reddish, finally black at maturity. This species is found growing in southern Europe, northern Africa, Algeria and the East. It grows wild along the shores of the Adriatic Sea and could be grown in Crimea and the Caucasus (21). In Algeria, it forms dense copses along the coast. It is also found under cultivation in the Canary Islands.

wild in Crimea on the southern slope of the peninsula from Sudah to Sebastopol at an altitude of 500 to 1000 feet as a tree, which ultimately reaches 30 to 40 feet in height and has a trunk diameter sometimes of enormous proportions. Medieval herbalists called trees of this species " Terebinthus ". Of all the species of the genus *Pistacia*, *P. mutica* more

FIG. 16. Trees of *Pistacia* species (possibly *P. mutica*) on dry hillsides in the Baluchistan area, south of Zahedan, near the Pakistan border of Iran. (Photo by Bembower)

7. *Pistacia mutica* Fisch. & Mey. is a tree up to 35 feet high (Fig. 16), the bark of which is dark brown with longitudinal fissures. Leaves deciduous, odd-pinnate; leaflets 2 to 4 pairs, oblong or oblong ovate, obtuse, petioles marginate or slightly winged, puberulent. Fruit a drupe, long obovate, flattened, obliquely apiculate. The heartwood is dark brown and very hard (7). It is native to Asia Minor, Iran and Afghanistan. It grows nearly resembles *P. vera*. Specimens a thousand years old are known.

8. *Pistacia terebinthus* L., a small deciduous tree (Fig. 17) reaching a height of 15 feet. Leaflets 9 to 13, mucronate, the petiole slightly winged. Flowers small, borne in axillary panicles, stamens purplish, stigmas red. Fruit is small, orbicular, slightly flattened, dark purple and wrinkled (10). This species is distributed throughout southern Eu-

rope, northern Africa, the East and the Island of Chios (21). Reference to *P. terebinthus* is found throughout the Bible. The Palestine Terebinth was described as a large deciduous tree, 12 to 25 feet tall, with straggling boughs and much the appearance of an oak when in its winter leafless condition. It is common on the lower slopes and hills throughout Syria, Lebanon, Palestine and Arabia Petrala, generally growing solitary, seldom in thickets or forests and found mostly in localities too warm or dry for oaks, which it generally replaces (26). There are great forests of *P. terebinthus* in Syria (21). In the time of Josephus (about 37–95 A.D.) there was a giant Terebinth tree near Hebron, which legend states had been there "since the creation of the world" and it is supposed to be the tree under which Abraham entertained the three angels (26).

FIG. 17. *Pistacia terebinthus* tree, Chico, California.

P. terebinthus and *P. lentiscus* are the two native species of Sicily (14). The carob and oleaster grow with the Terebinth but not as well, for their root system lacks the ability to penetrate as deeply in the soil.

Factors Influencing Selection of a Rootstock

Initial evaluation of the seven species which have been utilized as rootstocks upon which to grow the pistachio nut was based on disease resistance and their ability to grow under conditions of low soil fertility, low soil moisture or unusual cold. *P. mutica*, for example, is to be found growing on rocky sites in U.S.S.R. which contain extremely infertile soil. *P. khinjuk* grows in the wild on clay soils. *P. terebinthus* is preferred as a stock over *P. vera* in Greece because of its immunity from attack by foot rot, *Phytophthora parasitica*, and in Sicily because of its ability to grow well on rocky ground in the fissures of compact, volcanic calcareous rocks, withstanding the prolonged summer drought. This species does not occur naturally on the clay or deep, marshy soils. *P. vera* seedlings require a soil of medium texture which is deep, permeable and sufficiently moisture-retentive to prevent critical drying out. *P. atlantica* does well on the sandy north African soils.

In some countries, the early practice of planting seed or seedlings of *P. vera*, later grafting over to nut-bearing females (approximately 50 percent) has resulted in the establishment of pistachio orchards on their own species roots. This is a common practice in Iran. In recent years the wild trees in the hills near Kerman, Iran, have been grafted over to select seedling strains. While possible, topworking wild trees does not appear to be practical in areas such as this one, where spraying is necessary to control insects. *P. vera* possesses a well-defined taproot and strongly developed lateral root system (34) and its top grows fairly rapidly during the first five years and then slows down. It has been recommended as a rootstock for the pistachio tree but only if *P. mutica* seedlings are not available, since this species is preferred (21).

P. chinensis and *P. integerrima* are probably the only species in this group which are not found growing in close proximity to others in their native habitat. Good sets of nuts have been obtained as the result of intraspecific pollination among five of the eight species described (41), thus when species grow in close proximity to each other the question of the trueness to type of their seedlings will always arise. Falci (14) mentions an orchard of 1000 pistachio nut trees grafted on Terebinth obtained from the region of Sant'Angelo, Muxaro. It is highly probable that the seedlings used were hybrids rather than the true Terebinth types since in that area it is common practice to top-work the *P. terebinthus* trees to the pistachio nut, leaving a few Terebinth males to act as pollinizers. It is interesting that in a discussion of *P. terebinthus* Falci mentions finding four distinct types in the seedlings grown from seed obtained from different sources. Similar variations have been found in species seedlings grown from seed obtained from foreign sources and tested at Chico, California.

Harlan (16) reports that Turkish growers gather their rootstock seed from two areas (Fig. 7), one in the dry hills up in the Euphrates from Birecik, and the other from similar situations north of Gaziantep City. In these two areas the low-growing, shrubby *P. terebinthus* and *P. khinjuk* species grow wild bordering the cultivated orchards; thus the seed harvested from these areas is a highly variable genetic mixture of species hybrids. Rootstocks of such variability are considered desirable. Turkish growers are convinced that it is necessary to

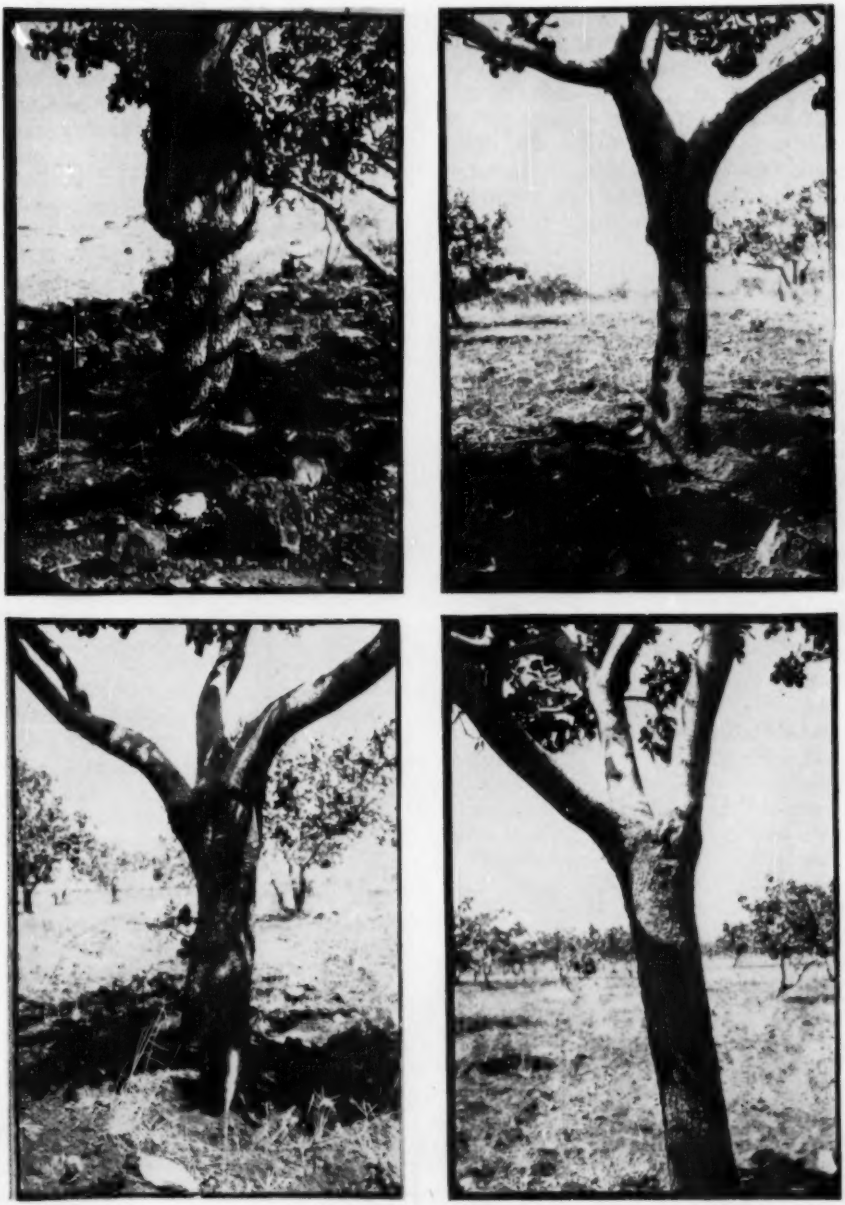

FIG. 18. Turkish pistachio varieties grafted on *P. terebinthus* seedlings (upper photos) show a varying degree of stock-scion incompatibility. Grafted on *P. khinjuk* (lower left) and on *P. vera* seedlings (lower right) show good union of stock and scion.

grow a tree with a strong root system and a less vigorous top on poor soil and one with a less vigorous root system and a strong top on good soil, otherwise they must wait ten to fifteen years for the trees to produce their first crops. Terebinth type seedlings are considered to have the "strong root" and to produce a dwarfing effect on the pistachio top growth. Dwarfing is caused by scion-stock incompatibility (Fig. 18), which, as might be expected considering the diverse nature of the rootstocks, exists in varying degree and is sometimes very striking.

Dwarfing of the pistachio tree is also considered desirable for ease in harvesting the nut crop and of great importance on the poor and sterile sites usually occupied by the orchards. *P. vera* and *P. khinjuk* types (Fig. 19), on the other hand, are compatible. Variations in longevity of the pistachio nut tree are due in part to the type of rootstock used, the pistachio lasting 150 years on *P. vera* rootstocks and 200 years on *P. terebinthus*, but only 40 years on *P. lentiscus* (18).

In the United States, seedlings of several *Pistacia* species are used as rootstocks, *P. atlantica* and *P. terebinthus* being two that have been tested and recommended. While seedlings of these two species make a slower growth in the nursery than those of *P. vera* or its hybrids with other species, they are more nematode-resistant than *P. vera* seedlings (19). The rootstock studies at Chico are also supplying evidence that pistachio varieties budded on these two species overtake and are superior in growth and yield to those budded on *P. vera*. Known species hybrids have been under evaluation as rootstocks for a considerable period. The variation in growth of the pistachio variety topworked on these rootstocks has been sufficient for us to question the use of seed from trees whose progeny have not been tested for superior rootstock performance.

Transplanting Trees to the Orchard

Pistacia species seedlings tend to be taprooted in the nursery and suffer considerable transplanting shock their first season in the field. Consequently, they should be transplanted to their permanent planting site as early as possible. They grow well once they become established. Transplanting has always been a problem. Many years ago in Italy, Mina Palumbo transplanted rooted suckers of *P. terebinthus* to establish new plantings but lost them during the summer drouth. He sent others to Calabria and Inzenga only to have more than half of them dry out and die enroute, while those that survived grew slowly and could not be grafted for many years. Rinaldo of Petralia saved only four of 480 rooted suckers of *P. terebinthus* he transplanted even though the work was done in winter (14).

Transplanting can be done any time during the dormant season, the sooner after the leaves fall in December or January the better. Likewise, planting as quickly as possible after lifting is essential. *Pistacia* roots are injured if exposed to the air for more than a few hours even though kept well dampened. All bare-rooted trees that cannot be planted at once should be heeled-in and the roots completely covered with soil until planting time. Thorough watering of each tree following transplanting will help reduce losses by compacting the soil around the roots. Seedlings that have reached sufficient size the first season in the nursery and have been budded can also be transplanted at this time. If the dormant variety buds fail to grow following transplanting, the seedling can be topbudded higher up on its trunk as soon as it has made sufficient new growth. Varieties propagated on well-established seedlings in the orchard soon catch up in growth with those propagated in the nursery prior to transplanting.

FIG. 19 (Upper). Low branching of deeply planted Iranian trees gives the appearance of several trees planted in the same hole. Trees planted as close as 10 feet require early thinning to prevent crowding. (Photo by Bembower)

FIG. 20 (Lower). One-hundred-year-old low-branching pistachio tree at Ardakan, Iran.

Only the top 60 to 75 percent of the seedlings should be selected for propagation and transplanting. The percentage varies from year to year but in any case the small, weak seedlings produce poor-quality trees in the orchard and should be discarded. Rootstocks have been grown in place by planting a few seed at each permanent location, selecting from them the best seedling growing at each site and removing the others. Although this method avoids problems in transplanting, it does entail the distribution of water to each planting site throughout the dry season rather than to a relatively concentrated location, such as a nursery or one's garden. Protective measures employed to prevent the drying out of nursery beds are applicable in this case.

Any of the several systems used in planting the various fruit or nut orchards can likewise be used in setting out an orchard of pistachios. The square system has equal distance between rows and trees within the row. The quincunx system has a fifth tree planted in the center of each square. The hexagonal or equilateral triangle system places the rows closer together but preserves the same distance between the trees. In any case, the minimum distance for pistachio trees in a permanent planting should be not less than 30 feet between trees. A distance of 32 to 35 feet would be even better. Closer spacing (Fig. 19), using filler trees, can be used if desired, until crowding requires their removal.

Soil Requirements

The wild pistachio tree has been found growing on the rocky soils of Lebanon, Palestine and the Isle of Cyprus. At Kushka and in the areas adjoining the lower course of the rivers Kafirnahan, Wakhsha and Kizel-Zu, the soil is composed of varicolored loose gypsoferous rocks of the Cretaceous and Tertiary period, as well as products of their disintegration, the loams and sandy loams rich in gypsum and carbonates. It is also found growing to a lesser extent on the loess-like loams of the foothills, the grey-colored, crystalline calcareous rocks and stony slopes lacking in gypsum and on the sandstone rocks without gypsum, such as those in the mountains of Kopet-Dagh.

The pistachio is thus a gypso-calciphilous plant, putting up with stony substratum, but always found growing on slopes with perfectly drained soil and unable to stand excess water in the soil (30). Although apparently adapted to all kinds of soil, it prefers relatively deep, light or dry sandy loams with high lime content. In Syria it grows well on chalky clay soil, well drained, but retentive of sufficient moisture for good growth. On rocky sites it prefers 25 to 30 inches of top soil, the roots extending into the rocky subsoil to get moisture. A southern exposure and a well-drained soil make a good combination. In Greece (5) pistachio trees on *P. terebinthus* rootstocks make good growth on the lime soils along the seashore of Phaleron and Aigina, which are poor and dry, and their growth response to applications of hard or salty water is excellent.

Other *Pistacia* species have their own soil preference, some mention of this having been made in discussing their use as rootstocks for the pistachio. In California, for example, *P. terebinthus* grows exceedingly well on dry, gravelly hillsides, but in one instance poorly on heavy, adobe-like soils underlaid with hardpan and not too well drained. Thus the soil preference of the *Pistacia* species rootstock must be taken into account in picking a site for a pistachio orchard.

Soil Moisture Requirements

The pistachio tree, because of the deeper soil penetration of its root system, is better able than other of the commonly cultivated fruit or nut trees to

withstand lack of soil moisture in the upper soil area.

In Turkey, which has an average rainfall of about 16 to 18 inches, irrigation is not practiced but care is taken to maintain a good dust mulch. In India there is sufficient retention of the large quantities of water supplied by winter rains to enable the pistachio tree to make good growth without summer irrigation. In Iran, where the average rainfall runs about 6 to 7 inches, land which cannot be irrigated is valueless for pistachio orchards.

Under the usual summer drought conditions prevalent at Chico, California, leaves on unirrigated pistachio nut trees usually turn yellow and begin to drop in August. When given an irrigation in July the leaves usually remain green and are retained until time for leaf fall in November. In an area with 18 or more inches of winter rainfall, at least two summer irrigations are necessary to maintain good tree growth. In drier areas, additional irrigations will be necessary for good tree performance. The response of the pistachio tree to good management practices is similar to that of other nut crop trees. Pistachio trees, like almonds, are sensitive to wet feet, and any system of intercropping should avoid excessive use of water around the trees. Mounding or ridging about each tree will aid in keeping standing water away from the crowns during irrigation.

Nutritional Needs

Little is known about the nutritional requirements of pistachio trees other than that they respond to applications of nitrogen the same as most other trees. Nutritional studies now in the planning stage will supply information on the benefits to be derived from applications of potassium phosphorus and other elements.

Analysis of soil samples from the first 6-inch and the 24- to 30-inch areas of Gh. R. Agah's Rafsendjan, Iran, pistachio orchards (38) gave a pH 7.7 to 8.0, indicating a normal soil condition in these areas. All contained slight accumulations of salt which would adversely affect plants sensitive to soil salinity. They were low in organic matter, nitrogen and phosphorus and an organic source of nitrogen and phosphorus, such as animal, fish meal or similar animal product, was recommended. An ample supply of potassium was available. It was also suggested that the trees be examined for minor element deficiencies, such as those causing iron chlorosis and manganese deficiency symptoms.

Climatic Requirements

It has been pointed out that the pistachio is a very xerophilous plant, able to stand great dryness of soil and air; humidity is unfavorable to its development. The pistachio tree thrives best in areas having cool enough winters for properly breaking bud dormancy and long, hot, dry summers for maturing the nuts. In Iran, for example, the best pistachio nut orchards are grown at an elevation of 4,000 feet on the extensive plateau which makes up the heart of that country and which is reputed to be one of the worst deserts in the world. Rainfall averages 10 to 15 inches a year, and in the south and east is less than 5 inches. Summer temperatures reach 100° F. in the northern portion of this plateau.

The Badkhys region of U.S.S.R. (34), where wild forests of pistachios are growing, is a semi-desert zone characterized by dryness of air, very significant cloudiness, low precipitation, hot summers and relatively cold winters. The pistachio tree flowers and produces fruit freely in England, but the summers are not warm enough for the nuts to ripen. In Syria it is found inland at an altitude up to 1200 meters where the air is dry. Annual rainfall at Aleppo is between 11 and 15 inches, the rainy season occurring from

January to March and the dry one from May to October. Bronte, Sicily has a mean summer temperature of 73.4° F. and a mean winter temperature of 46.0° F., but the temperature has dropped to 26.6° F. without harming the trees.

Under the dry, arid climate of Arizona pistachio trees have survived a winter temperature of 6° F. without injury. They flourish in eastern Iran where temperatures vary from 15° F. in the winter to 108° F. in the summer, and grow well in the interior San Joaquin and Sacramento valleys of California, where somewhat the same temperatures are experienced. The wild trees of the Kuska, U.S.S.R. region withstand winter temperatures below zero ° F. (15).

The pistachio grows and fruits well as far south as Bakersfield, California, but beyond there, particularly around Los Angeles, production is irregular, the trees bearing good crops of nuts only after fairly cold winters or at altitudes sufficiently high to provide winter temperatures similar to those of the San Joaquin Valley. At Indio, California, where a thriving date industry exists, the pistachio nut cannot be successfully grown. *P. atlantica* of North Africa thrives here as would be expected. At Sacaton, Arizona, a crop of pistachio nuts is borne only one year out of five on the average, for in most years there is not quite enough cold weather to break bud dormancy and delayed foliation occurs. The 4.4° F. difference between the seven-year average January temperature of 44.9° F. recorded at Kerman, Iran, where the climate favors the growth of pistachios and the 30-year average of 49.3° F. at Sacaton is indicative of the borderline position Sacaton occupies (8). Little is known of the northern limits of pistachio growing although it is believed that in areas with a shorter growing season than that of the Sacramento Valley, it might be difficult to mature and harvest the crop, especially when the fall rains and cool weather start in September. In general, areas adapted to almonds and olives are suitable.

As a rule, the trees do not blossom early enough to suffer seriously from spring frosts, but there are occasional seasons when unusually late frosts will destroy most, if not all, of the blossoms. The well-known botanist, Ernest A. Bessey, while exploring for plants in Turkestan in 1902, reported that a late April frost killed all the pistachio nut bloom. It is estimated that in 1956 frost in certain areas of Iran reduced the crop 25 percent. These are not isolated cases; there is frequent mention in the literature of crop losses throughout the pistachio-growing areas due to late spring frosts.

Early Growth and Training

Pistachio trees are long-lived and relatively slow growers as compared with other deciduous fruit trees. Since they do not make too dense tops, there is little need for more than light pruning during the early development of trees if they are properly trained. The maximum top and root growth that results insures earlier bearing.

When the seedling is budded close to the ground and the variety bud is allowed to grow with little or no pruning or training, *P. vera* forms a medium-sized, bushy tree which hugs the ground. In Iran, trees are allowed to develop a bushy, spreading habit (Figs. 19, 20) to facilitate harvesting the clusters of nuts by hand from the ground or from the low-growing larger branches.

For the grower who is not concerned about cultivating under his trees this may be satisfactory provided the lateral scaffold branches do not originate so close together that they press upon one another as the tree matures. If this occurs, there can be splitting-out at the trunk because of the pressures that develop. Destruction of trees by splitting-out of the lateral branches just as they

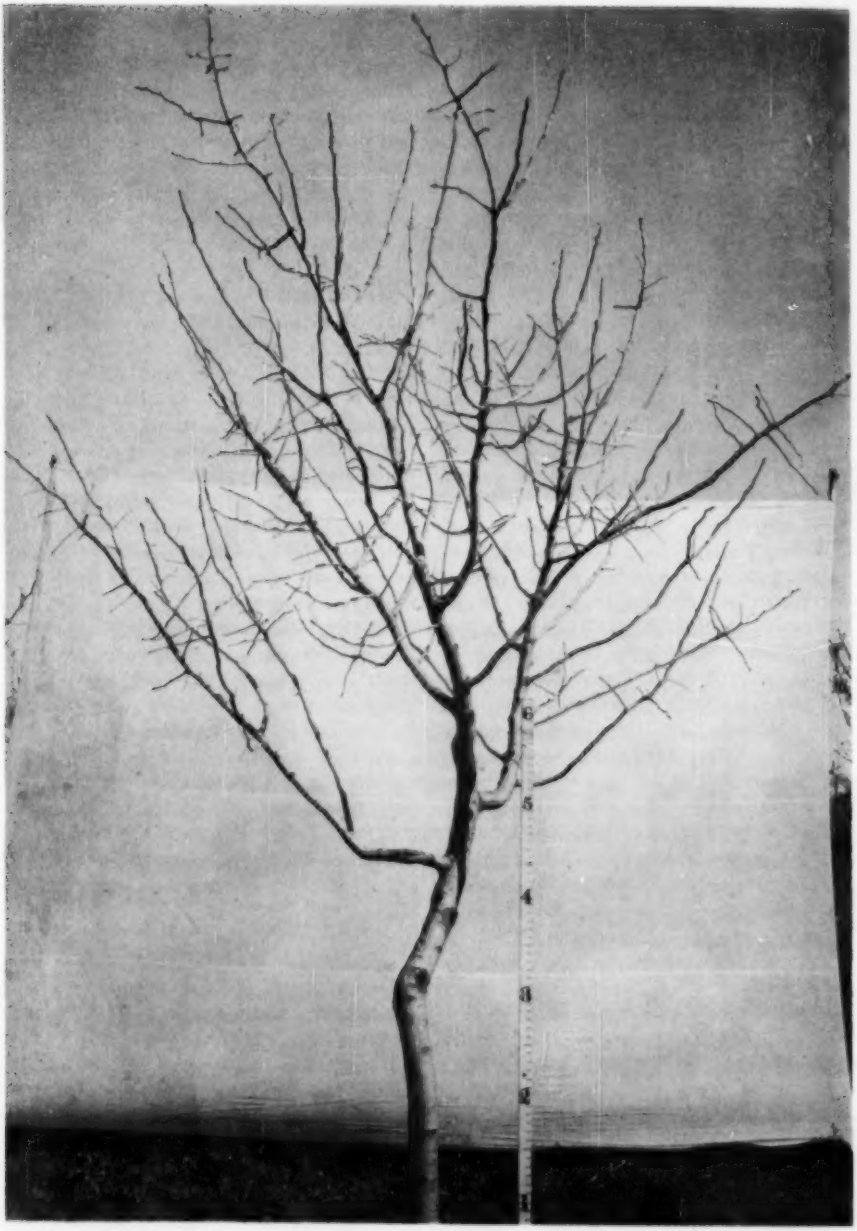

FIG. 21. Six-year-old, high-headed pistachio tree, showing strong, well-spaced scaffold branches.

reach good bearing age represents a serious loss to the grower.

While it is possible that in some instances a bush form of tree may be desirable, the high-headed type lends itself to more efficient orchard operation, both in cultivation and in harvesting. In the case of the high-headed tree the problem is one of early training for apparently little is needed otherwise, at least not until after the tree reaches bearing age and matures so that growth slows down. A modified leader type of training (Fig. 21) produces a tree whose scaffold branches, when well spaced along the tree, are capable of bearing heavy crops without breaking.

In its formative stages the pistachio nut tree produces a moderate number of long, upright branches that tend to become pendulant, apparently because of lack of sufficient lignification. This pendulant type of growth is a peculiarity of the pistachio tree that must be taken into account throughout the early training period. During the first year or so in the orchard, young trees of most varieties require staking to keep them upright. Bracing the long, weak scaffold limbs in position with lath or some similar support, until they are thoroughly lignified, assists materially in forming a well-shaped tree and does away with pruning back misshapen branches. High heading also provides somewhat for the pendulant growth and does away with the necessity of cutting off larger branches just as the tree reaches bearing age.

Pruning cuts on pistachio trees should be confined to branches of small diameter. Wounds two inches or more across tend to heal over slowly, thus providing a ready entrance of decay organisms into the exposed wood. On large wounds there is a tendency for death of bark tissues around and below the cut. Unlike most fruit trees, when the food supply of tissues surrounding a branch is cut off by loss of the sustaining branch, apparently these tissues are not always able to obtain new food supplies rapidly from nearby sources. Painting the exposed wounds immediately with one of the commercial non-toxic asphalt emulsions is not only helpful in reducing decay but appears to be helpful to the healing process.

Pruning Bearing Trees

Observations of the growth and bearing habits of experimental plantings of the pistachio at Chico, which have now reached their fifteenth year, suggest that lack of pruning may be detrimental to efficient production. As the trees reach bearing age and the more or less pendulant limbs are pulled downward and closer together by the weight of the crops, there is a tendency to fill in the gaps with new growth. With each addition of new growth, more and more of the fruiting wood in the shaded areas gradually dies; the nut-bearing region is thus gradually confined to the more exposed outer area of the tree. Since pistachio trees, like peaches, produce their flower buds on current-year growths, a light, thin-wood type of pruning should be initiated as needed, keeping in mind the fact that only enough small diameter cuts should be made to let in light and stimulate the production of good fruiting wood throughout the tree.

Fruit Bud Development and Gametogenesis in *Pistachia vera* L.

In many crop trees, floral differentiation occurs in the calendar years prior to blossoming. Exceptions are the pistillate flowers of pecan and walnut. Those who have studied this floral differentiation have recorded yearly and varietal fluctuations in the dates of first floral differentiation. Jones (20) initiated the first studies of pistachio fruit bud formation as it occurred at the U. S. Plant Introduction Station at Chico,

California. Although the diploid number of chromosomes in various members of the family Anacardiaceae was on record as ranging from 30 to 60, he found no previous report of the number of chromosomes in any species of the genus *Pistacia*. However, in Darlington and Wylie's 1955 edition of the Chromosome Atlas of Flowering Plants, Zohary has since recorded diploid chromosome numbers of 24 for *P. lentisicus*, 28 for *P. atlantica* and 30 for *P. vera*. Available in thesis form only, Jones has approved the inclusion in this article of his summary of the work:

" Trees of *Pistacia vera* L. are dioecious and deciduous. On these trees the fruit buds are differentiated during the calendar year prior to blossoming.

" When terminal vegetative growth starts in the spring, the axillary primordia may develop into either fruit buds or vegetative buds. Each young primordium has a rounded apex with a uniseriate tunica. During April and May the axis of each primordium which will form a fruit bud elongates and branches, whereas the axis of each primordium which will form a vegetative bud does not elongate or branch. The elongation and branching of the axes of these young buds during April is considered to be the first sign of fruit bud differentiation.

" The branch structure of the staminate and pistillate inflorescences is formed within the fruit buds in April and the first three weeks of May. While these fruit buds are rapidly developing, all apices within them are rounded, are vegetative in appearance and function, and have a three- to four-seriate tunica. Within the staminate buds all apices become floral in nature in the latter part of May; within the pistillate buds this change takes place in the first part of June. These floral apices are broad and nearly flattened; the tunica is uniseriate. These apices are determinate and will produce stamens or carpels only. As each apex within either a staminate or pistillate inflorescence bears only one flower, it is established that the number of flowers produced on a given inflorescence is determined by the number of branches formed within the fruit buds during April or May of the year prior to blossoming.

" Stamens are differentiated in the latter part of May, and for about three weeks their growth and differentiation is rapid. By June 7 archesporial tissue is visible within the anther lobes. Growth of the staminate buds and the stamens is now essentially complete for this season. In the following spring the subsequent growth of the anthers and the formation of the microspores and microgametophytes are normal in all respects.

" Over-all growth in size of the pistillate buds is complete for the season by June 1; however, carpels are not differentiated until late fall in the varieties Red Aleppo and Trabonella, or until the following spring in the variety Bronte. The major growth of the ovary occurs during the latter part of February and throughout March of the season in which the flowers mature. The provisional interpretation is made that this ovary is composed of one large functional carpel and two smaller carpels. There is one ovule, which is considered to be orthopterous with a bent funiculus. Development of the megagametophyte follows the " normal " or monosporic eight-nucleate type of development. Chalazogamy is noted in this species.

" Mature staminate and pistillate flowers are apetalous. The trees are completely dioecious; no rudimentary floral organs are found in either the staminate or pistillate flowers. The term thyrsus is applicable to both the staminate and pistillate inflorescences.

" The diploid number of chromosomes in *Pistacia vera* L. is 32; the haploid number is 16 ".

Pollination Requirements

As early as 1697, the pistachio tree was recognized as dioecious, that is, the male or staminate and the female or pistillate flowers (Fig. 22) are borne on different trees, and that it is wind pollinated. In a description of the ancient practice of artificial pollination in Sicily there is mention of the earlier flowering of the males and the necessity of collecting the pollen in a small bag and scattering it over the female flowers as soon as they open or of collecting and drying the male flowers and applying them to the female. It is interesting to note the comment that this procedure was adopted when the trees of the two sexes grew apart; otherwise the action of the wind sufficed to effect natural fertilization, since in that case there were always some male flowers whose period of opening corresponded to that of the females (27). Falci (14) refers to the male sometimes flowering twenty days in advance of the female. The recommended ratio of male to female plants for adequate pollination varied from one to three to as low as one to twenty females.

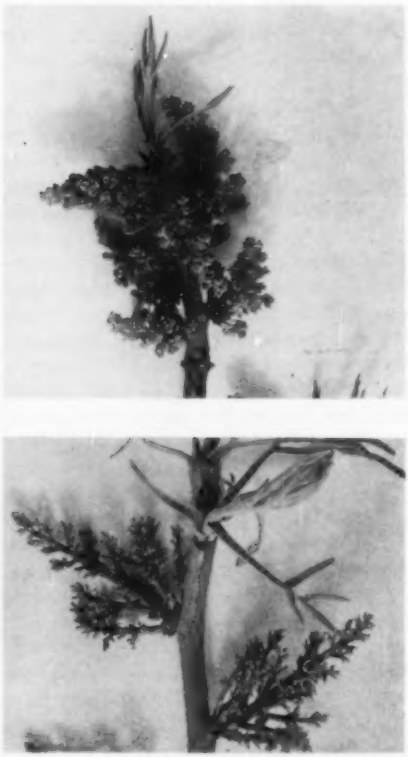

FIG. 22. Male flower clusters (upper) dehiscing pollen; female clusters (lower) shortly after pollination. Terminal bud vegetative.

Most of the rather limited amount of precise information available on the floral biology of the pistachio up to 1941 was embodied in publication by Falci (14), Savastano (33) and Agnostopoulas (4). A four-year study (1937–40) of the pollination requirements of the pistachio at the Chico Station revealed that the flowering periods of the *Pistacia* species males other than *P. vera* tend to be earlier than those of the pistachio varieties (44) and that while there is some overlapping, there is not enough to insure a good set of nuts. Variation in order of flowering of the different species and varieties as affected by the weather is of slight consequence, but more than one male variety is likely to be needed for consistent pollination of fruiting varieties, since these fluctuate among themselves. Consequently male pollinators must be selected that shed their pollen at the time the female blossoms are receptive. In the past, one male to each ten females has been the recommended ratio, but currently it is believed this can be increased to twelve females for each pollinator.

Topworking a limb of a variety to a male scion instead of planting a male tree, while feasible, is not recommended because of the tendency of the nonbearing male limbs to outgrow the rest of the tree.

In earlier writings, mention is made of *P. terebinthus* pollen producing a

higher set of pistachio nuts than that of *P. vera*. In the work at Chico, there was no important difference in the set obtained with different pollens tested, whether the pollination was intraspecific or interspecific, which could be attributed to incompatibility or low viability. Of the pollinators studied, Chico No. 23 and Peters have proven satisfactory for the range of Red Aleppo and Trabonella bloom. Peters is suitable also for Kerman, Damghan and Lassen, varieties which tend to reach full bloom stage several days later than Red Aleppo and Trabonella. It serves as an excellent pollinator for the early part of their blossoming period, but to insure good pollination at all times, a male with a blooming period slightly later than that of Peters is needed. Of the several under study, one or two appear promising as supplemental pollinators to fill this gap.

Falci (14), commenting on the effect of Terebinth pollen on the development of the pistachio nut, notes that drupes on trees nearest to male Terebinthus have a tendency to open their valves at the top (shell splitting) which he feels is due to an increase in size of the kernel directly attributable to pollen. No evidence of pollen effect on shell splitting was obtained from the work carried on at Chico, where pollen from a number of *Pistacia* species, including that of *P. terebinthus*, was used to pollinate flowers of several pistachio varieties. Pollen of *P. chinensis* delayed the ripening of the nuts, an effect previously recorded (28) at Sacaton, Arizona. When moisture, nutrition, size of crop and other factors which influence the growth of the nut are taken into consideration, the difficulty of measuring effect, it any, of pollen on kernel development is understandable.

Diseases and Insects

Pistachio trees grown in this country have rarely suffered serious damage from insects or diseases. Kouyeas (23) identified *Phytophthora parasitica* Dastur as the causal agent of a foot rot which attacks and kills young pistachio trees when irrigation water does not drain away from the base of the tree readily or through basal wounds. The damage is restricted to the cambium and is similar to the brown rot gummosis of citrus or the ink disease of chestnut. The optimum temperature for the development of the fungus is about 32° C. (89.6° F.), but Kouyeas found that injury is more apt to occur in the spring when cooler temperatures prevent the plants from secreting resins in great quantities. *P. terebinthus*, the usual rootstock for the pistachio in Greece, is immune from the disease. The killing of young pistachio trees as the result of not protecting their trunks from standing irrigation water has occurred in newly planted orchards in California.

Septoria spp. (13, 29), which cause leaf spotting and consequent defoliation and will through repeated defoliation year after year weaken the tree until it dies, are found in other pistachio growing countries. Fortunately, they are easily controlled through the use of copper sulphate spray. Anagnostopoulos (5) states that in Greece the pistachio is subject to severe injuries by fungus parasites in all stages of its development. Of these, the most serious is a fungal parasite of the genus *Phomopsis* which attacks the female flowers in the spring, starting at the tips and extending over all or part of the cluster. It becomes inactive in the summer and resumes its activity in the early fall, when it frequently destroys entire clusters of fruits as well as the midribs and petioles of the leaves. The fungus gains its entrance through insect punctures, principally those of a lepidopterous insect, *Tinea pistaciae* Anagnos. Control programs consist of burning infested plant parts and the application of oil sprays in

January to destroy the overwintering stage of the insect. Some assistance is obtained from its natural enemies, the animal parasites.

Similar damage may be done by a *Fusarium* sp., which is also a causal agent of the drying of the fruit. *Fusarium* and other secondary fungi follow

curs on *P. vera* and practically all of the species of *Pistacia*. Fortunately, this disease does not cause serious injury.

Kreutzberg (24) discovered a new virus disease on a wild pistachio tree in the Badkhyz Mountains, Turkmenia, U.S.S.R., in 1935. Later it was also observed in Uzbekistan and Tadzhikistan.

FIG. 23. Gall formation of small roots of *Pistacia* seedlings caused by root knot nematode, *Meloidogyne* sp.

Phomopsis in its work of destruction; therefore, insect control measures that check the spread of *Phomopsis* serve also to check the others. Additional control is obtained by the application of three Bordeaux mixture sprays at specified intervals. Fall applications of this spray are used to control the leaf spot. In countries other than the United States, a rust fungus, *Uromyces terebinthi*, oc-

When attacked, the pistachio tree forms rosettes of varying size presenting a dense interlacement of short, thin branching twigs. Growth of the tree is seriously checked.

The virus is transmitted by insects and seed. A survey during 1936 and 1937 indicated that the area of infection was confined to those forest tracts of Turkmenia, Uzbekistan and Tadzhiki-

FIG. 24. Growers at Damghan, Iran, under the direction of the United States Operations Mission, are rejuvenating neglected orchards. (Photo by Bembower)

stan, where the pistachio tree is growing, as well as to the adjoining regions of northern Afghanistan and northern Iran. Sixty-two percent of the plantations in the Kushkinskaya forest were infected and yields of infected trees were reduced approximately one-third.

Root-knot-nematode injury (Fig. 23) has been observed and recorded (19) at Chico, California. Pistachio nuts, stored at room temperatures, suffer from storage moth infestation, the larvae feeding on the kernels. Processors have found that storage at low temperature and relative humidity control moth infestation.

In Iran (8) some twenty-five harmful insects are known. The more serious of these have been under study in recent years by both local and American entomologists through a United States Operations Mission technical aid program, and control methods (Fig. 24) have been successfully developed. Of these, a sap-feeding leafhopper, *Idiocerus stali* Fieber, a psyllid, *Agonoscena targionii* (Licht.) and several root- and nut-boring beetles have been controlled by DDT sprays. Another nut borer whose larvae feed on the kernels and overwinter in the nuts is controlled by burning the infested nuts before the adult insects emerge in the spring. Bark beetles are reduced by removing and burning infected branches (36).

In the Damghan and Ghazvin areas of Iran, insect pests have increasingly damaged pistachio crops over the past two decades until the crops have hardly paid for harvesting costs. In 1954, initiation of insect control measures (8) helped increase yields in Ghazvin from a 300-ton crop in 1953 to a 2,000-ton crop. In the Damghan area (31) trees that were sprayed to control insect infestation produced a heavy crop for the first time in five years, whereas the nuts in unsprayed orchards were again largely destroyed by insects. Other factors, as for example the large amount of starch stored in the trees during the preceding, unproductive years, no doubt contributed to the more than average crop response. The results demonstrate that continued control of insect pests will help keep the orchards productive.

Yield, Harvest and Preparation for Market

The pistachio nut tree, like those of apples and some other fruit trees, is a biennial bearer, i.e., it bears a heavy crop of nuts one year and little or none the next. The pistachio tree, like the almond, bears a few nuts four or five years after planting in the orchard, but does not begin to produce well until it reaches ten years of age. Fifteen-year-old pistachio nut trees, in experimental plantings at Chico, have already produced several good crops. An average of the first five crops will provide a fairly reliable estimate of what to expect in the way of yields during the first twenty years of a well-cared-for orchard.

In Iran trees start bearing some nuts at seven and reach peak production at 20 years of age. Yields obtained from old orchards, as previously noted, are reported to run from 100 to 150 pounds of marketable nuts per tree.

A great deal is yet to be learned about efficient harvesting and handling of the nuts. The fruit is a drupe. In California, it matures in late August and September and occasionally in early October. At maturity, the external portion of the fruit changes from a light green to a pale, straw or whitish, opaque appearance (Fig. 25), at the same time softening and loosening itself from the stony inner part of the ovary wall, which is the gray-white inner shell. Thus, it is easily slipped off by pressing between the fingers. Often the shell splits naturally along a longitudinal suture. Splitting of the shell facilitates opening the nuts by hand and thus is desirable from

the consumers' point of view. Within the shell is found an edible seed containing an embryo composed of two large, fleshy cotyledons, a small radicle and a small plumule. The cotyledons are different from those of most other seeds in that they contain a green pigment.

Under normal conditions the nuts hang

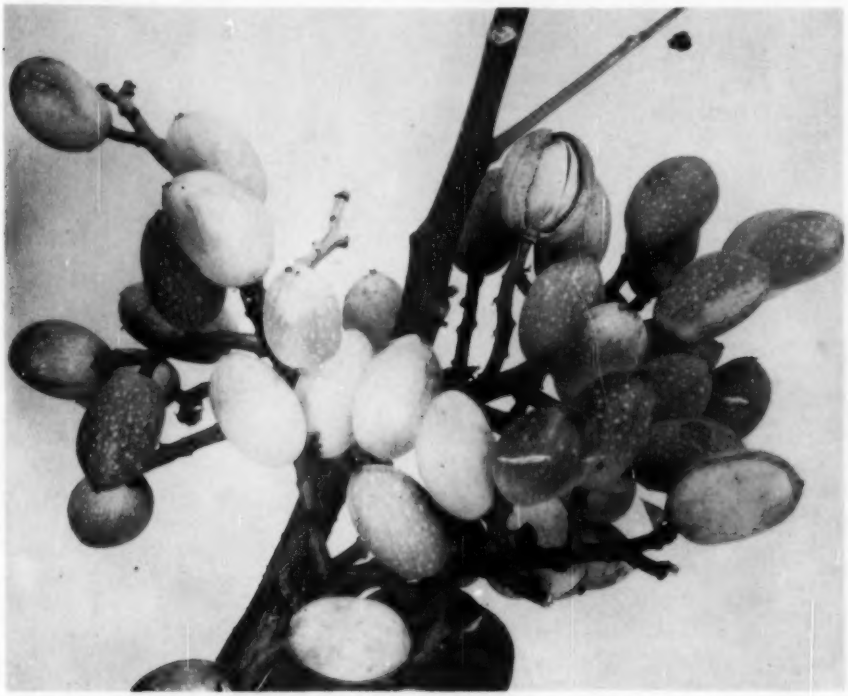

FIG. 25. Pistachio nuts are ready for harvest when the green or reddish husk becomes translucent and separates from the shell.

well, so that, if the crop is left on the tree until most of the nuts are ripe, all that are well filled are harvested in one picking. In Iran, most growers spread burlap or cloth under the tree to catch the clusters which, after picking by hand, are thrown to the ground. Some throw the clusters on the dry soil. After harvest, the clusters of nuts are placed in bags and carried to a central location, where the mature nuts are removed from the stems and the outer husks are removed by hand (Fig. 26). The husks of a small percentage of the nuts, which are over-mature or immature, adhere to the shell but are readily removed after a short period of soaking in water. Nuts which for one reason or another lack fully developed kernels float on the surface of water and are easily removed. The nuts are dried in the sun on stone, concrete or dry earthen floors. After drying they are put in bags and placed in storage rooms for curing. Grading is done in the villages by shaking the nuts through coarse sieves or by hand. Additional grading is usually required before sale to dealers (8).

In Turkey, the freshly harvested nuts are pulled from the clusters, thoroughly dried and then stored with the hulls intact in heavy gunny sacks. Storage insects do more damage to hulled nuts than to unhulled ones. The nuts are processed for recrushing and also to separate those with split shells from the unsplit. Empty nuts are removed by screening (Fig. 27), and unsplit nuts after washing are cracked by hand (Fig. 28). Most of the nuts are sold through marketing coopera-

FIG. 26. Gh. R. Agah, pistachio grower and exporter (right), examinining pistachio nuts at Ferdousi Village near Rafsenjan, Iran. Nuts are hand hulled and sorted by Iranian women in the background. Oct., 1955. (Photo by Bembower)

as orders for them are received. After the dried nuts are soaked in water, revolving stone rollers are run over them until the hulls are loosened from the shell. A fanning mill, which separates chaff from grain, is used to separate the nuts from the moist pulp. Hand labor is required to remove the unhulled nuts

tives, which have been in existence for many years (9).

In California, pistachio nuts are knocked off the trees with poles or shaken onto canvas sheets and then sacked. They are not easily knocked off with rubber mallets as are almonds. If held in sacks over twenty-four hours,

heating occurs, the soft external hull breaks down and spoils, and the shell and kernel become discolored (Fig. 29). Drying can be accomplished on trays set out in the sun or in artificial dryers. Rapid surface drying soon after hulling helps to prevent the development of surface molds.

In the United States preliminary investigations of mechanical procedures are under way which will make it possible to (1) remove the soft, external hull immediately after harvest, (2) separate the empty nuts from those with well-developed kernels and (3) separate the nuts with split shells from those whose shells are closed. Enough progress has been made to suggest that satisfactory removal of the hull by mechanical means will present no difficulty. Removing empty nuts, a number of which develop with or without pollination, is not difficult. Separating the nuts with split shells from those whose shells are closed appears to be the most baffling problem, and that is the one for which there must be an answer before the nuts can be economically prepared for marketing in this country.

FIG. 27 (Upper). In Turkey, empty nuts are removed by screening. (Photo by Zenobia Co.)
FIG. 28 (Lower). Italian girls crack each unsplit shell with pliers. (Photo by Zenobia Co.)

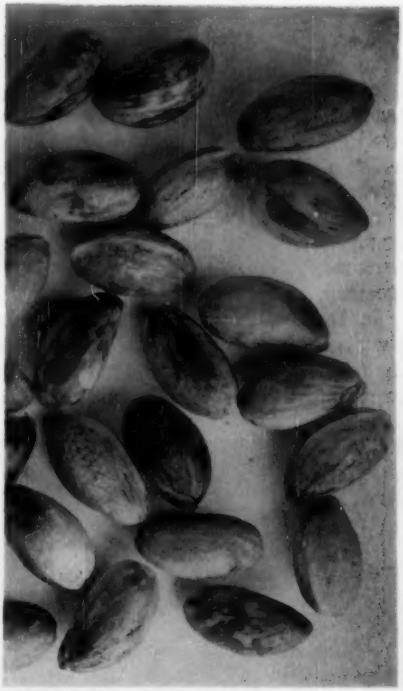

FIG. 29. Crushing the resinous husk during its removal stains the light colored shell and reduces saleability of nut.

Uses Made of Pistacia Species Tree and Fruit

The ancients ate pistachio nuts as an antidote against liver troubles and as an aphrodisiac. The Arabs of today consider them good for the digestion as well. Rhazes (Persia) discussing coffee says: "He that would drink it . . . let him use much sweet meats with it and oyle of

pistachios and butter . . ." (6). In the countries bordering the Mediterranean, small bags of nuts are given to each guest at social affairs and they have long been a favorite at wedding feasts. They are the favorite sweetmeat of the harem ladies of Egypt and Syria. The delicious French " chicken galantine de volaille " is made with ham, white meat of chicken, and pistachio nuts inside, and the whole perfumed with sherry, larded and steamed.

In Iran (8) the hulls removed from the pistachio nuts at time of harvest are used for fertilizer and small amounts are made into a flavorful marmalade. Those

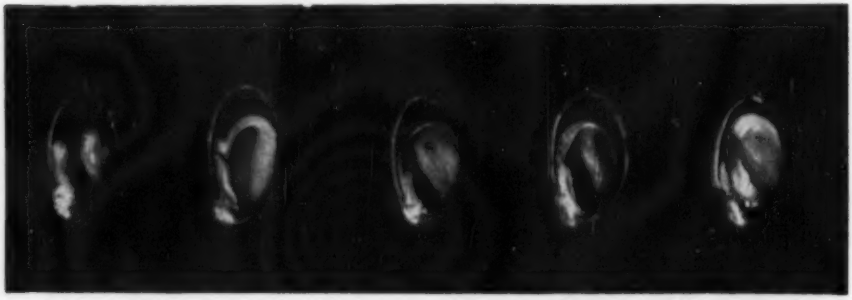

FIG. 30. Stages of Bronte pistachio nuts development July 7, 1939. Husk and bony shell of pistachio nut complete most of their growth before initiation of kernal development.

of *P. atlantica* called " gadum " are eaten by natives of the Algerian Sahara and very likely in Tripoli, notwithstanding their turpentine taste. The fruits of trees of *P. cabulica* Stocks., common to the low hills of eastern Afghanistan, are prepared for use as a warm, stimulating remedy for colic and dyspepsia.

The Persians were known as terebinthe eaters. The rules for the King's table, which were inscribed on a pillar in the palace, included terebinthe oil as a daily article of food. Persian youths were brought up to live in the open air and depend on terebinthe berries, acorns and wild pears as sources of food. Cyrus wondered at the bravery of the terebinthe-eating Persians, who were destroying his hosts.

The fruits of *P. terebinthus* are preserved while yet immature, along with stems on which they are borne, by the use of vinegar and salt. Known as " atsjaar " these preserved fruits are used as a sort of pickle dish to supplement wines served during dinner. The Armenians eat them while observing their fasting rite. The Caucasians use the richer flavored fruits of trees growing in the Caspian Sea area, in preference to those growing in the interior. The writer during his travels in Iran ate pistachio nuts prepared in this manner and found them delicious. Since the fleshy cotyledons of the kernel do not start development until after the shell has hardened (Fig. 30), the greater part of the " atsjaar " probably consists of pickled stems and pericarp.

Most *Pistacia* species trees form galls on the leaves as the result of aphid and possibly other insect stings. The large yellow galls which develop on the leaves of *P. khinjuk* are full of resin. The galls are known as " Gool-i-Pista ", the resin as " Aluk-ool-Unbat ". *P. cabulica* develops red gall-like excrescences like the comb of a cock growing from the midrib of the underside of the leaf. The resins of both species are used as a mastic.

Galls and resinous gums of the wild pistachio tree of northern Afghanistan and Iran are exported to India, the gum resin "Shilm-i-Pista" being used as a medicine.

The wild pistachio of U.S.S.R. is utilized for its resins and for its galls, which are a source of tannin and the dyes used to color wool and silk. An aromatic resin is present mainly in the bark, leaves and outer husks of the fruit. Whenever the tree is wounded or scalded by fire, the resin is produced copiously, protecting the wound until healing can take place. Information obtained from tapping tests carried out by the Russians on *P. vera* males in Turkmenia has been used in estimating that 50 tons of resin could be collected yearly from the one and one-half million male trees of wild pistachio growing in this region. Because of high solubility in some solvents, this resin is used in making paint, oil and nitro varnishes. The resin of *P. mutica*, the turpentine or "Kero" tree of the Crimea (2), is also used in the preparation of nitro varnishes.

The Ancient Greeks knew a tree common in Asia Minor and on the islands adjacent which they called "terebinthos" and which the Latins and later writers called "Terebinthus". The terebinthe was mentioned as growing in the Paropamisus Mountains, the only tree in the frightful desert through which Alexander passed on his way to Bactriana. It yielded valued turpentine to the Semitic peoples (21) in Petraian Arabia, Judea, Syria, Cyprus and in the Cycladea. This large, handsome tree was sometimes called the turpentine tree; it yielded the true "Chian or Cyprus" turpentine of the pharmacists. This is probably the reason for its being called by this name in Ecclesiasticus. It was known to the Egyptians and Greeks as early as the sixth century before Christ, as is proved by a small jar (17) found among the ruins of Naucratis, then the only Greek colony in Egypt. The resin in the jar was found to be identical with the Chian turpentine.

In Syria large quantities of turpentine liquid are collected in skins or clay vessels fashioned in the form of a swallow's nest, allowed to harden and transported to villages. Later it is heated to the point where liquid and produces a product which in color and firmness resembles white shoemakers' gum, in which form it is displayed for sale in the bazaars and perfumers' shops in Iran, Turkey and Arabia. It is said to relieve catarrhal troubles by stimulating the flow of body liquids, to give whiteness and hardness to the teeth and gums and to sweeten the breath. Since it is native to Gilead, it is possible that its resinous juice formed part of the "spicery" which the Ismaelites carried to Egypt from Gilead. On the other hand, the "balm" of Jacob may have been the product of the lentisk or mastic tree (26). The oriental custom of chewing the mastic gum of the *P. lentiscus* tree can be compared to the American habit of smoking tobacco, which has spread all over the world.

"Today mastic is employed primarily in the manufacture of high grade transparent varnishes for special purposes. The elasticity of such varnishes is quite high, and for centuries they have served as protective coatings for fine paintings, being readily removed by friction or solvents without injury to the paintings. The gelatinous material known to artists as 'megilp' (from McGuilp, its inventor) consists of mastic, turpentine and linseed oil.

"Mastic has been used also in photography and in cements for precious stones and their imitations. A surgical varnish containing mastic, castor oil and benzene is said to be used as a protective covering for wounds and to hold gauze and radium needles in position. In addition to these uses in spirit varnishes, lacquers and adhesives, there has been

utilization also in some lithographic processes and as a constituent of incense" (25).

P. lentiscus nuts contain 20 to 25 percent of edible oil known as "Shina oil of Cyprus". Oil of this species extracted in Spain is used for eating as well as burning in lamps. The residues from the extraction of the oil are rich in tannins. The oil content of the pistachio nuts varies from 51 to 62 percent, wild Afghanistan nuts yielding the high oil content. The oil content of Asperon varieties is higher than the greenish colored, aromatic nuts of the Crimea (22). In southeastern Afghanistan (40), an oil is obtained from nuts of *P. khinjuk*.

The wood of *P. chinensis* is valued for its toughness (43) and is used in cart building and to make the finest rudder posts for Chinese junks, and that of the pistachio tree is excellent for cooking and heating. *P. integerrima*, called zebra-wood in India, is much prized for carving and cabinet making because of its hard, beautifully mottled heartwood.

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Utilization Abstract

Drug Plants of Ceylon. This paper, the concluding part of the author's account of Singhalese drug plants, contains accounts of the botany, history, culture, composition, and uses of the following: derris (*Derris elliptica*); euphorbia (*Euphorbia hirta*); fennel (*Foeniculum vulgare*); *Azadirachta indica*, a substitute for gentian; ipecacuanha (*Cephaelis ipecacuanha*); linseed (*Linum usitatissimum*); nutmeg (*Myristica fragrans*); nux vomica (*Strychnos nux-vomica*); cajeput (*Melaleuca leucodendron*); chaulmoogra oil (*Taraktogenos kurzii*); croton oil (*Croton tiglium*); hydnocarpus oil (*Hydnocarpus wightiana*); castor oil (*Ricinus communis*); sandalwood oil (*Santalum album*); sesame (*Sesamum indicum*); mustard oil (*Brassica nigra*); oil of theobroma (*Theobroma cacao*); papain (*Carica papaya*); pelletierine tannate (*Punica granatum*); picrotoxin (*Anamirta paniculata*); black pepper (*Piper nigrum*); pyrethrum (*Chrysanthemum cineriaefolium*); quassia (*Picraena excelsa*); rauwolfia (*Rauwolfia serpentina*); senna leaf (*Cassia acutifolia* and *C. angustifolia*); stramonium (*Datura stramonium* and *D. tatula*); strophanthus (*Strophanthus sarmentosus* and *S. hispidus*); tamarind (*Tamarindus indica*); tonka bean (*Dipteryx odorata* and *D. oppositifolia*); and ginger (*Zingiber officinale*). (D. M. A. Jayaweera, *Trop. Agr. 113(1): 45–85. 1957.*)

JOHN W. THIERET

The Pepper Tree, *Schinus Molle* L.

Schinus molle, *in its native habitat, Peru, is used variously as a mildly alcoholic beverage (fruit), medicine (leaf extracts and sap), and infrequently as a yellow dye and tannin. The species has been introduced into Mexico, the southwestern United States and southern Europe, but in none of these areas is the plant much more than an infrequent ornamental.*

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In the Cordilleran region and on the west slope of Peru is found a small tree or shrub which is called *Molle* or *Mulli* by the Peruvians (21, 24). It grows normally along water courses and elsewhere only in the higher regions (15). Its vertical distribution is from sea level —although it avoids the immediate coast —to 2300 m. in northern Peru, to 3000 m. in central Peru. Occasionally it is found on the Atlantic slope of the Peruvian Andes (Ceja de la Montaña) as one of the few representatives of western flora, where it disappears between 2800 and 2900 m. (15). It is an evergreen tree, but there appears some contradiction on this point: Weberbauer states (p. 158): ". . . Schinus molle bleibt . . . immergruen und unterscheidet sich dadurch von der Mehrzahl der Straeuche", while Meyen (26, p. 169) writes: "In the parched regions of the western coast of Peru, I have seen . . . our Fig-tree standing next the Schinus, both leafless and apparently dried up". Molle belongs to the genus *Schinus* of the *Anacardiaceae* or Sumac family. It has pendulous branches and yellowish-white flowers arranged in clusters. The fruits are coral-red, the size of peppercorns, with a bony kernel enclosing a single seed (13, 14).

The Molle is probably the best known and most widely distributed member of its genus, which comprises some 15 to 20 species. It is found also in the Andean countries bordering on Peru, south to Chile (3) and north to Ecuador (10) and Colombia (9). It is also described from Paraguay (22), Uruguay and southern Brazil (20). In the last three countries it may, however, not be *Schinus molle* which is described, but *Schinus aroeira*, a variety, which probably was introduced there (29) in post-Columbian days.

Molle seemed to have been—and apparently still is—an important tree to the Peruvians. Three parts of the tree are used: the fruits, the juice of the leaves, and the sap of the trunk. The fruits, which contain Piperine, an alkaloid (6), are soaked in warm water, the bitter seeds are squeezed out and removed, and the water which has dissolved the sweet meat of the fruits is strained and left standing for some days. Bruman (5) quoting Garcilaso de la Vega describes a slightly different procedure: "The seed when ripe has on the surface a little sweetness which is very tasty and pleasant, but beyond that the rest is very bitter. They make a drink from that seed by rubbing it gently between the hands in hot water, until it has yielded all its sweetness. They must not

arrive at the bitter portion, for otherwise all is spoiled. They pass that water thru a sieve . . .". This produces a pleasant and healthy wine-like drink which subsequently may be cooked into syrup or fermented into vinegar (24, 20). The leaves are filled with a volatile oil which is used medicinally for ophthalmia (9) (" contra las nubes de los ojos ", 22), and for rheumatism. When the bark is cut, a milk-like sap flows easily. This sap is comparable to mastix. Applied externally, it is used against pains and swelling of the legs, as a remedy for swellings and sores generally, and also against the " darkness of the eyes " (24). Taken internally the sap is a purgative (20, 24, 27) and a diuretic (9, 32).

The tree also contains tannin (4, 9) and the leaves give a yellow dye (4, 20); no reference, however, was found if and to what extent the Peruvians make use of these two properties. The Peruvians held the tree in high esteem and dedicated it to their deities (3, 24).

It appears from the references consulted that *Schinus molle* was unknown outside of South America in pre-Columbian days. There is no documentation of the exact time of its transfer to Mexico. Bruman (5) describes the situation as follows:

> " Its common sixteenth century name in Nahuatl was pelonquauitl (pelon, ' Peru '; quauitl, ' tree '), which would indicate a Spanish introduction. . . . According to a hoary tradition the Viceroy Mendoza sent some seeds of the plant to Mexico after his transfer to Peru in 1550. It may be so, though no documentary proof seems to have been found. Francisco Hernández does not mention Mendoza in his description of the tree, though he was a most painstaking worker, and present in the area within two decades after Mendoza's transfer. More probably *Schinus molle* was introduced into Mexico at some time in the early 1540's, when there was a fair amount of contact between the two regions ".

Pickering (29), referring to Hernández and Humboldt, states that the tree, together with the potato, was introduced in Mexico after the time of Montezuma. Saunders (31) quotes Charles F. Lumis as crediting Mendoza with sending the tree " up to Mexico about the year 1540 ".

The use of the Molle for medicinal purposes seems to disappear in Mexico. Neither is it used as a source of beverages, but only as an ingredient of the pulque (resulting in a drink called copaloctli) and of quebrantahuesos (" bone breaker ", a concoction of cornstalk juice, toasted corn, and ripe molle seeds). Two other minor and not well documented uses are given. One source states that the tree was " supposedly . . . introduced by the early Spaniards in order to procure wood in the volcanic district " (17), another source (27) tells that the tree is used as a host for a cochenille (Schildlaus) from which a butter-like fat is gleaned. This fat, upon exposure to air, forms a hard red crust which is used for medicinal purposes as well as a lac.

The spread of the tree in Mexico is credited to birds which eat the seeds freely (17). Ridley (30) lists six species of birds which eat, among others, the fruits of the Molle, to which they are especially attracted by the red color.

Although a species of *Schinus*, perhaps the one seen by Columbus, as mentioned by Pickering (29), is native to Jamaica (25), the Molle does not appear there. The only mention of it pertaining to the West Indies is by Edwards (11) who states that *Schinus molle* was introduced by Hinton East of Jamaica in his botanical garden there in 1783.

Molle is widely distributed through Mexico (22) which may be the reason that it is occasionally thought to be native to that country (16).

Schinus molle was introduced into California from Mexico, although here also documentation is lacking as to the exact time. The Mission of San Luis Rey in San Diego County is generally given the distinction of having been the place of

original introduction. Saunders (31) was informed by Mrs. Mary M. Bowman of Los Angeles " that when Don Juan Warner, famous in the early history of California, stopped at that Mission in 1831, the Father Superior showed him a bed of queer plants growing in the Mission garden. The Father did not know what the plants were, but said that a sailor on a vessel from the southward had once given him a package of the seeds, unnamed. The packet was overlooked for some years, but finally the Father had the seeds sown out of curiosity to learn their nature. They proved to be Pepper Trees, or as the Spanish-Americans called them at that time and still do, *arboles del Peru*. . . . All died, except the original in the garden which still [1914] stands ". This account may well be more legend than historical fact. The present distribution in the United States is north to the San Francisco Bay area and east as far as western Texas.

In Europe the tree appeared earlier than in California. According to Schube as cited by Hegi (20) it was cultivated in the Renaissance in Silesia (!). Linné in 1777 (24) states that Molle grows in the open air in Spain and Italy; Hernández in 1790 (21) mentions it in Spain (" A Peruina regione in hanc Novam Hispaniam, imo Hispaniam Europeam planta, quam Molle vocant, jamdiu est advecta atque translata "). It was first described as early as 1579 (35) by the Dutch botanist Karl Clusius, also by Tournefort in 1700 (23, 24) and Miller in 1731 (24, 28). It subsequently became very widespread in Spain, Italy, and on the French Riviera (3). One author (8), writing about the Riviera, indicates how popular the tree is there (" in almost every garden and in the open places of the town . . .") although " it doesn't always thrive well in Nice ". In the Mediterranean area Molle occurs as far east as Egypt (40).

Schinus molle was also carried to Hawaii and Queensland (40) but no references were found as to the time of dispersal to these two areas.

The use of the Pepper Tree has declined considerably. Neither in California nor in Europe was the tree used for any of the purposes for which it was so highly esteemed in Peru. Now it is used only as an ornamental. As such it became popular because of its pretty leaves, its wide, shade-giving crown, its yellowish flowers and reddish berries (4, 20, 39). It has, however, lost some of its earlier popularity in some quarters. " Its low pendent branchlets and falling fruits make the Pepper Tree undesireable for planting near sidewalks " (25); also " people . . . grumble at the Pepper Tree because of a disposition to drop its leaflets too freely in wet weather, so contributing rather markedly to the dirtiness and slipperiness of sidewalks " (31). In California it has been found that the tree acts as a harbor for scale insects (40) which are detrimental to citrus trees, and consequently thousands of trees have been cut down. It is also susceptible to Oak-Root-Fungus disease and Armillaria Root Rot and many trees have been removed for this reason (33, 34).

The authorities seem to agree as to the area of origin of *Schinus molle* on the water courses of the temperate Peruvian Andes. Inasmuch as it was a very useful tree to the inhabitants of this area, it is probable that they have cultivated it as well as contributed to its spread before the fifteenth century. No records are preserved which would allow a glimpse of how this plant got started. It is interesting to note that the area of use of Molle coincides with part of the area where fish poisoning, an ancient trait, was practiced and where the people were familiar with the chemistry of plants.

The tree was then presumably brought to Mexico around 1540 or 1550 by the

Spanish, where it was planted and spread by man and birds.

It was then brought to Europe in the early eighteenth century, probably first to Spain from where it was dispersed by man to other Mediterranean countries. It was also brought to southern California probably late in the eighteenth century from where it spread through part of the southwestern United States. It was also carried to Hawaii and Queensland.

The use of the tree becomes markedly less intensive in each one of these three stages of dispersal. From the intensive use in Peru as a source of medicine, beverages, and possibly dye, it declines to minor usage in the intermediate Mexican stage, to become a not quite satisfactory ornamental tree in the third stage. This pattern is reminiscent of certain plants which were important in primitive stages of man, such as fish-poison plants (e.g.: *Erythrina* and *Sapindus*), which have been carried by man far from their home and as this trait faded, they were still planted casually as ornamentals beyond any utility.

The tree does not seem to have undergone great changes during its known period of cultivation. It may be noted however that whenever it is described in its native habitat it is referred to as a shrub-like tree or even as a shrub, while later in the areas of the third stage of dispersal it is described as a small tree (14), 20 or more feet high (13) or 15 to 50 feet high (25).

The work that has been done on the *Schinus molle* is sparse. Much of its background is obscure and distorted by legend. Much remains to be done and surprising facts may well be uncovered. The writer is informed by Professor C. O. Sauer that some botanists have discovered differences between the Peruvian and the Mexican Molle which led them to believe that two different trees are involved

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Utilization Abstract

Sago. True sago is a starch obtained from the trunks of certain palms of Malaya, Indonesia, Borneo, Sarawak, Brunei, and New Guinea. The most important sago palms are *Metroxylon sagus* and *M. rumphii*. These grow thirty to fifty feet high and have trunks from fifteen to eighteen inches in diameter. Sago palms are usually propagated by suckers. A sago palm flowers when it is about fifteen years old, and, after fruiting, it dies. The rootstalk survives and sends up new shoots. Both wild and cultivated palms are utilized. Some 74,000 acres are thought to be under productive sago. Average yearly yield per acre is about thirty palms and 225 bushels of undried, crude sago flour. Recoverable starch in a mature trunk was found to be about 40% by weight, a yield probably not obtained by the crude methods of extraction usually employed. Starch content is at a maximum after flowering but before fruit formation. The palm may be felled either at this time or at an earlier stage of its growth. The trunk is cut into three- or four-foot lengths for transport to a village. After the soft and woody "bark" (about 1 1/2 inches thick) is removed, the starchy pith is grated into material resembling sawdust. From this the starch is extracted by trampling the material with water on raised mats. The starchy water that trickles through the mats is caught in troughs in which the starch settles out. When a trough is full, the wet, crude sago is removed and sold to traders. At the traders' depot the starch is washed further and finally dried in the sun.

In the manufacture of pearl sago, top quality starch is powdered and passed through 1/6-inch-gauge sieves. Then it is subjected to a rocking motion, causing the grains to form into small spheres. These, in turn, are passed through sieves of 1/7-inch gauge and then gelatinized by frying in vegetable oil. Finally the product is baked and passed through 1/8-inch-gauge sieves.

In 1955, 9921 tons (value £ 234,905) of sago starch were exported from Sarawak and North Borneo. In the same year, 33951 tons (value £ 856,300) of sago starch and 5619 tons (value £ 207,920) of pearl sago were exported from Malaya, the majority going to Great Britain.

Roasted slices of fresh sago pith can be eaten like toast, and the crude starch baked to produce sago biscuit. The pith is suitable for fodder or poultry feed, and sago refuse is fed to pigs. Good quality sago starch can be used in custard and gravy powders, sauces, and in lemon curd. The main utilization of the starch is for sizing and finishing of cotton warps. Although sago, as still made by primitive methods, is no longer the cheapest starch, a good potential demand exists for the product because many starch users prefer sago. (R. M. Johnson and W. D. Raymond, *Colonial Plant and Animal Products 6(1): 20–32. 1957.*)

JOHN W. THIERET

An Attempt to Determine Possible Taxonomic Significance of the Properties of Water Extractable Polysaccharides in Red Algae

More than sixty species of red algae have been described as containing significant quantities of polysaccharide hydrocolloids. There seem to be three major types of these polysaccharides. It is the purpose of this paper to determine the degree of correlation between these and the morphological and reproductive criteria used to establish the groups of algae.

LEONARD STOLOFF [1] AND PAUL SILVA [2]

The validity of a natural system of classification of organisms is proportional to the breadth of its base. Data may be derived from comparative morphology, anatomy, cytology, cytogenetics, biochemistry, physiology, reproduction, life histories, and ecology. The greater the number of criteria used and the greater the correlation of factors obtained, the more likely will a taxonomic arrangement express phylogenetic relationships. After a system of classification has been developed on the basis of several sets of criteria, as in the red algae (Rhodophyta), applying an additional set usually provides evidence of confirmation rather than of disagreement. Any discrepancies which thereby result might raise doubts as to the accuracy of the data or the validity of generalizing from the data, even if accurate. On the other hand, such discrepancies might indicate places in the arrangement that should be scrutinized in terms of re-evaluating previous data. Thus it is always profitable to bring additional data to bear on taxonomic questions. Moreover, in the present instance, the additional data are derived from biochemical components which are of commercial value, so that the classification becomes a matter of economic interest and importance.

The use of chemical components in classification is not novel. Harvey (9), in establishing the major groups of algae that he called Melanospermeae (brown algae), Rhodospermeae (red algae), and Chlorospermeae (green algae), made use of a biochemical character—pigmentation—which is now known to be related to fundamental physiological processes and to be correlated with fundamental structural differences. In many red and brown algae the intercellular substance is composed in large part of polysaccharides having unique properties. It is the purpose of this paper to determine the degree of correlation between the types of polysaccharides and their distribution in groups of algae previously established on morphological and reproductive criteria, insofar as available data permit. Although the remainder of this discussion will be concerned with the red algae, similar considerations could be applied to the brown algae.

More than sixty species of red algae have been described as containing significant quantities of polysaccharide hydrocolloids, of which probably no more than a dozen are used commercially.

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Because of their intercellular location, strong affinity for water, adsorptive properties and ion exchange nature, there can be little doubt that these polysaccharides play an important role in the physiology of the plant. Based upon the limited knowledge of structure and physical characteristics available to us at present, there seem to be three major types of polysaccharides. Information on chemical structure in most cases is meager so that physical properties of the polysaccharide sols have have been relied upon for the major portion of this provisional classification, which is an amplification of a very similar one proposed by Sauvageau (21).

Agars are non-electrolytes (3). The electrolytes associated with agars are difficult to remove so that this criterion is only approached by the evidence of a markedly lower ash content than in the other two groups. Agars form sols of low viscosity that set to strong thermally reversible gels at distinctive temperatures with gel strength and gelling tem-

TABLE 1

LISTING OF SEAPLANT GENERA AND SPECIES ACCORDING TO DOMINANT TYPE OF WATER EXTRACTABLE POLYSACCHARIDE

Agars

Acanthopeltis japonica (2, 21)
Ahnfeltia plicata (17, 28)
Campylaephora hypnaeoides (= *Ceramium hypnaeoides*) (21)
Ceramium boydenii (2)
Corallopsis salicornia (6)
Digenea simplex (12, 13)
Endocladia muricata (24)
Gelidiella acerosa (= *Gelidium rigidum*) (6)
Gelidium amansii (2)
" *arborescens* (25)
" *arbuscula* (21)
" *attenuatum* (21)
" *cartilagineum* (6)
" *corneum* (15)
" *crinale* (5)
" *japonicum* (2)
" *latifolium* (5, 21)
" *nudifrons* (25)
" *pacificum* (2)
" *pristoides* (15, 22)
" *pulchellum* (21)
" *pulvinatum* (21)
" *pusillum* (21)
" *sesquipedale* (21, 22)
" *subcostatum* (2)
Gracilaria armata (12)
" *blodgettii* (12, 22)
" *caudata* (12)
" *cornea* (12, 14, 22)
" *henriquesiana* (18)
" *lichenoides* (4, 21, 23)
" *multipartita* (12, 22)
" *taenioides* (6)
" *verrucosa* (= *G. confervoides*) (19, 22, 27)
Phyllophora nervosa (17)
" *hubens* (17)
Pterocladia lucida (23, 28)
" *pinnata* (= *P. capillacea*) (21, 23)

Carrageenans

Aeodes orbitosa (15)
Chondrus canaliculatus (22)
" *crispus* (22)
" *ocellatus* (22)
Eucheuma cottonii (22)
" *edule* (6)
" *muricatum* (= *E. spinosum, E. denticulatum*) (6, 22, 28)
Gigartina acicularis (21, 22, 28)
" *asperifolia* (24)
" *canaliculata* (24)
" *decipiens* (22)
" *pistillata* (21, 22)
" *radula* (15, 16, 22)
" *stellata* (= *G. mamillosa*) (22)
Gloiopeltis coliformis (1, 20)
" *furcata* (6, 11)
" *tenax* (1, 6, 20)
Gymnogongrus norvegicus (21, 22)
" *patens* (21)
Iridaea laminarioides (7, 10)
" *capensis* (= *Iridophycus capensis*) (16, 22)
" *flaccida* (28) (S. & G.) Silva, comb. nov. (*Iridophycus flaccidum* Setchell & Gardner, Proc. Nat. Acad. Sc. 23: 171 (1937))

Gelans

Agardhiella tenera (12, 22)
Furcellaria fastigiata (21, 22)
Hypnea cervicornis (6)
" *musciformis* (6, 14)
" *spicifera* (22)
Suhria vittata (22)

Unclassified

Dilsea edulis (5)
Dumontia incrassata (5)

perature relatively unaffected by other solutes. The gels have a very wide differential between gelling and remelt temperatures. This type includes but is not restricted to those hydrocolloids employed for gelling bacteriological media or described in the U. S. Pharmacopoeia (26).

Carrageenans*, including Irish moss extractive, are salts of sulfate esters having a ratio of sulfate to hexose units close to unity. Sols of these products are viscous. They can be induced to form thermally reversible gels whose strength and gelling temperature are dependent on specific cations, particularly potassium and ammonium. A distinctive property of these polysaccharides is their ability at relatively low concentration to alter the degree of agglomeration of the casein particles in cow's milk. Because the change in the casein is probably associated with the formation of a complex between the carageenan and the serum proteins of the milk, this property might be considered akin to an antigen specificity, denoting a common molecular configuration. A similar specificity occurs with regard to the formation of precipitates with methylene blue (8).

Gelans—Polysaccharides of this type are similar to carrageenans with respect to sol viscosity and gelation properties, but lack the specificity in causing casein agglomeration and precipitation of methylene blue. The few reliable determinations of ester sulfate indicate values in the range of 0.5 per hexose unit. The only name, outside of the general term "gelose", that has been applied to any hydrocolloid of this type is a trade designation. Because all known hydrocolloids of this type are strong gel formers, a tentative name "gelan" appears to be appropriate.

* The use of carrageen*an* instead of carrageen*in* is based on a recommendation of the Committee on Nomenclature of the Division of Organic Chemistry, A.C.S.

It is interesting that the quantitative hydrocolloid content seems to fall into ranges distinctive of each group. Agars usually compose 15–20% of the dry plant weight, gelans 15–25%, and carrageenans 50–75%.

In Table 1 are listed the seaplants from which polysaccharides of these types have been extracted. It should be emphasized that in many cases the analytical data are too meager to permit but a tentative assessment of the polysaccharide and that in many cases the taxonomic identification of the sample is open to question, especially among the species of *Gelidium* and *Gigartina*.

It may be seen from this listing that all species of the same genus have the same type of water extractable polysaccharide. When the genera are listed phylogenetically, however, as in Table 2, discrepancies within families appear. For example, agar is found in *Endocladia* and carrageenan in *Gloiopeltis*, both members of the Endocladiaceae; within the Phyllophoraceae, agar is found in *Phyllophora* and *Ahnfeltia*, carrageenan in *Gymnogongrus;* and within the Gelidiaceae, agar is found in *Gelidium*, *Gelidiella*, *Pterocladia*, and *Acanthopeltis*, whereas gelan is found in *Suhria*. The finding of carrageenan and gelan within the same family is less disturbing, inasmuch as we might expect a close relation between these two types on the basis of enzyme degradation studies of Yaphe and Baxter (28). This same work emphasized the structural difference between agar and the sulfated polysaccharides. On the ordinal level little can be concluded in view of the availability of but scanty data from Nemalionales, Cryptonemiales, Rhodymeniales, and Ceramiales. Within the Gigartinales all three types of polycassharides are found. Gracilariaceae would seem to have only agar and Gigartinaceae only carrageenan.

Environmental factors to which a plant

TABLE 2

TAXONOMIC ARRANGEMENT OF SEAPLANTS WITH INDICATION OF TYPE OF WATER EXTRACTABLE POLYSACCHARIDE

Rhodophyta	
Florideae	
Nemalionales	
Gelidiales	
Gelidiaceae	
Acanthopeltis	Agar
Gelidiella	Agar
Gelidium	Agar
Pterocladia	Agar
Suhria	Gelan
Cryptonemiales	
Dumontiaceae	
Dilsea	Unclassified
Dumontia	Unclassified
Endocladiaceae	
Endocladia	Agar
Gloiopeltis	Carrageenan
Grateloupiaceae	
Acodes	Carrageenan
Gigartinales	
Furcellariaceae	
Furcellaria	Gelan
Solieriaceae	
Agardhiella	Gelan
Eucheuma	Carrageenan
Hypneaceae	
Hypnea	Gelan
Gracilariaceae	
Corallopsis	Agar
Gracilaria	Agar
Phyllophoraceae	
Ahnfeltia	Agar
Gymnogongrus	Carrageenan
Phyllophora	Agar
Gigartinaceae	
Chondrus	Carrageenan
Gigartina	Carrageenan
Iridaea	Carrageenan

is exposed might reasonably be expected to influence the polysaccharide. A study (22) made on plants of a few species growing under various conditions showed a wide variation of properties within a polysaccharide type but no instance of the occurrence of another type. These results tend to support the validity of attributing taxonomic significance to the correlations indicated above, but by the same token equal significance must be attached to the discrepancies.

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The Influence of Certain Factors on the Acidity and Sugar Content of the Jersey Blueberry[1]

Cultivation of blueberries in the United States is of rather recent origin. As production from commercial plantings increases, more attention must be given to quality factors. This study is devoted to such factors as correlation between berry size and seed, acid, and sugar content.

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Introduction

While the fruit of the blueberry has been harvested from the wild since colonial times, the culture of this fruit as a crop dates back only to the early part of the present century. It began in New Jersey about forty years ago, and, a few years later, experimental plantings were made in Michigan. On the Pacific Coast, the first plantings were made after 1930 in both Oregon and Washington.

Today, blueberry culture is expanding rapidly in the United States wherever climate and cultural conditions are favorable. In the Pacific Northwest, this fruit gives promise of becoming an important adjunct to the small fruit industry, particularly in the areas west of the Cascade Mountains. Trial commercial plantings are also being made in the San Francisco Bay region of California.

Until 1953, little research had been done pertaining to the quality factors in the blueberry. Casual observations, however, had indicated that sweetness and sourness were in some way related to the size of the individual berries, and, size appeared to be correlated with seed development. In this study, therefore, an attempt was made to determine to what extent size of berry is correlated with sugar and acid content, and to what extent size is related to seediness. Other possible quality determiners considered in the study were the time of picking and the use of certain fertilizers or plant nutrients.

While the results obtained suggest fairly positive conclusions, the study must be regarded as being of a preliminary or exploratory nature.

[1] Part of a Master's thesis submitted to the Department of Horticulture, Oregon State College, Corvallis, Oregon, 24 April, 1957.

Edible Species of Blueberry

Authorities generally recognize six important botanical species of edible blueberries, all of which are indigenous to the United States. These belong to the genus *Vaccinium* as distinguished from the huckleberries which are usually grouped in the genus *Gaylussacia*. The six species are as follows:

V. membranaceum Dougl.—The Mountain Blueberry. Native of the high slopes of the Cascade Mountains in Washington and Oregon.

V. ovatum Pursh.—The Evergreen Blueberry. Native along the coast from central California to British Columbia.

V. pallidum Ait.—The Dryland Blueberry. Native to the Ozarks and

southern Appalachians and isolated areas as far north as New England.

V. ashei Reade—The Rabbiteye Blueberry. Native to the river valleys and edges of woods in northern Florida, southern Georgia and Southern Alabama.

V. australe Small (V. corymbosum L.) —The Highbush Blueberry. Native from northern Florida to southern Maine and west to southern Michigan.

V. augustifolium Ait.—The Lowbush Blueberry. Native of northern United States from Maine to Minnesota and south as far as Pennsylvania and West Virginia.

The cultivated varieties of blueberries are derived almost entirely from the highbush type. While a few of the varieties are selections originally made from the wild, most of them are the results of hybridization carried on by the United States Department of Agriculture and, to a lesser extent, by private hybridizers working mostly in the Pacific Northwest. Among the best known commercial varieties are Jersey, Stanley, Dixie, Pemberton, Concord, Weymouth and Burlington. Of these varieties, Jersey is by far the most popular in Oregon, and for that reason it was the variety chosen for this study.

Although interest in the blueberry now centers largely around the cultivated types, large quantities of the fruit are still gathered from the wild plants of several species. In fact, the fruit of *V. angustifolium* gathered in Maine and neighboring states still accounts for approximately 60 percent of all the blueberries utilized in the United States. As production from commercial plantings comes in, however, it is expected that the wild fruit will become less important.

Review of Literature

Since the blueberry is comparatively new to the horticultural world, its literature is meager and incomplete. This is particularly true of literature pertaining to the chemistry of the blueberry. The writer found it necessary, therefore, to review the literature of other small fruits such as the blackberry, raspberry, cranberry, strawberry, currant, and grape where research has been carried out correlating the composition of the berry with environmental and cultural factors.

Several investigators have found a relationship between seediness and berry size. In both blueberries (6, 7, 19) and grapes (15, 16) the larger berries contained the most fully developed seeds, and seed weight seemed to correspond with berry size.

There was one reference which did not agree with the results of the other investigators. Merrill (13) reported in pollination experiments conducted at Michigan State College in 1936 that no relationship was found between size of berry and the number of seed per berry after testing four hundred open-pollinated Rubel blueberries for seed content and berry weight.

The experiments reported are not entirely consistent as to the effects of fertilizer treatments on the acid and sugar content of small fruit (5, 9, 10, 11, 12). No reports, however, show any significant relationship.

The results obtained by the various workers with regards to the relationship between time of picking and sugar and acid content again were not entirely consistent. Shoemaker and Green (17), when testing the effects of fertilizers on strawberry composition, also noted the effects of time of picking: where the pickings were two days apart, the acidity went down between the first and third picking but rose again between the third and fifth picking. The percent of total sugar regularly increased between the first and fifth picking. Kaiser, Pollard and Timberlake (10), also studied the effects of time of picking on strawberry composition. Two tests, made in 1951

and 1952, show that the acidity of the berries went down, though not regularly, between the first and sixth picking. During the first test the sugar content rose irregularly between the first and sixth picking. During the second test, however, the sugar content decreased between the first and sixth picking.

Methods and Materials

Samples were taken in the summer of 1953 from the fertilizer test plots at the Lewis Brown Farm near Corvallis. The bushes at the time of sampling were eight years old and had been bearing for the past six summers (Fig. 1).

FIG. 1. Blueberry fertilizer test plots at the Lewis Brown Farm. The row of small bushes (nearest to the road) are pollinizers.

The plots had been mulched with fir sawdust, and the depth at the time of sampling was about six inches. The fertilizer treatments were first applied during the spring of 1946 when the plants were one year old. There were nine different fertilizer treatments (two plots per treatment) applied at the following rates: 100 lbs. of N per acre (N); 50 lbs. of N per acre (urea); 0.2 lbs. of borax per acre, 2 lbs. of magnesium sulfate per acre, 1 lb. of manganese chloride per acre, 2 lbs. of zinc sulfate per acre and 1 lb. of copper sulfate per acre (minor); 10 lbs of sulfur per acre (S); 100 lbs. of K_2O per acre (K); 100 lbs. of P_2O_5 per acre (P). The urea was applied two years later than the rest. The bushes were planted six feet apart in rows eight feet apart.

The plants were in better than average condition during the summer of 1953. The winter of 1953 was warmer than usual, and the temperature and moisture conditions during the blossoming period were normal. June was wetter and cooler than normal and the weather during the ripening period was also cooler than normal. It is believed that these weather conditions delayed ripening for about one week beyond the normal ripening time. The week preceding the third picking (28th August) was especially cool.

Time of Picking and Sampling

Samples were taken from all of the eighteen plots except #2 (NP), which was accidentally missed, during the first picking on the 28th July 1953. During the second and third picking, 12th and 28th of August, respectively, samples were taken only from plot #9 (NPK). About three to four pints of berries were taken from each plot.

Each sample was further divided into five size groups, each containing 50 berries. A sizing device was constructed (Fig. 2) consistsing of two fixed diverging strips of wood. The narrowest space was 11 mm. and the widest 17 mm. Marks were made at 12, 13, 14, 15, 16 mm. as well. The sizing device was placed over six containers, each 2¼ inches wide (labeled A to F), and the berries placed one by one, by hand, rolling them toward the wider opening so that they fell through the portion of the slot corresponding to their average diameter. This procedure was continued until fifty berries were obtained for each size group. Table I shows the arrangement of the size groups and the diameter and average weight per berry in each size group.

TABLE I

SIZE GROUPS: DIAMETER AND AVERAGE WEIGHT PER BERRY

Size group	Diameter (mm.)	Average weight per berry (grams)
A	16–17	1.83
B	15–16	1.54
C	14–15	1.30
D	13–14	1.05
E	12–13	.84
F	11–12	.69

After sizing, each group of fifty berries was placed in a polyethylene bag and stored at 34° F. None of the berries were out of refrigeration more than two days. The time under refrigeration, before running laboratory analysis varied from two to four weeks.

Laboratory Analysis

The approximate sugar content of the berries in these experiments was determined by testing for soluble solids with a hand refractometer, as outlined in physical and chemical methods of sugar analysis by Browne and Zerban (3). While soluble solids and actual sugar content are not synnonymous terms, for practical purposes the percent of soluble solids is a close approximation of the sugar content, since the soluble solids other than sugar constitute but a small fraction of the cell sap. As pointed out by Tingley (18), the sugar and soluble solids content of melons and squashes were found to be practically the same, in studies carried on at Cornell University. Other investigators report similar results with other horticultural products.

In using the hand refractometer, it is often found necessary to dilute the juice samples with water, since the pure juice is often too dense in color to permit a satisfactory reading. Consequently, the samples were diluted with an equal amount of distilled water. As pointed out by Brown and Zerban, however, the readings are from 0.61 to 0.75 percent higher for diluted juice. Since the purpose of this study was to compare samples rather than to make exact chemical determinations, it was felt that this error could be overlooked, particularly since the refractometer readings themselves are accurate only to the nearest 0.2 percent. The same procedures were used on each sample, therefore increases or decreases in soluble solids between samples should not be materially affected by this error.

After weighing and dilution, each sample was placed in a Waring Blendor and agitated at slow speed until all of the seeds had separated from the pulp. The length of the agitation time de-

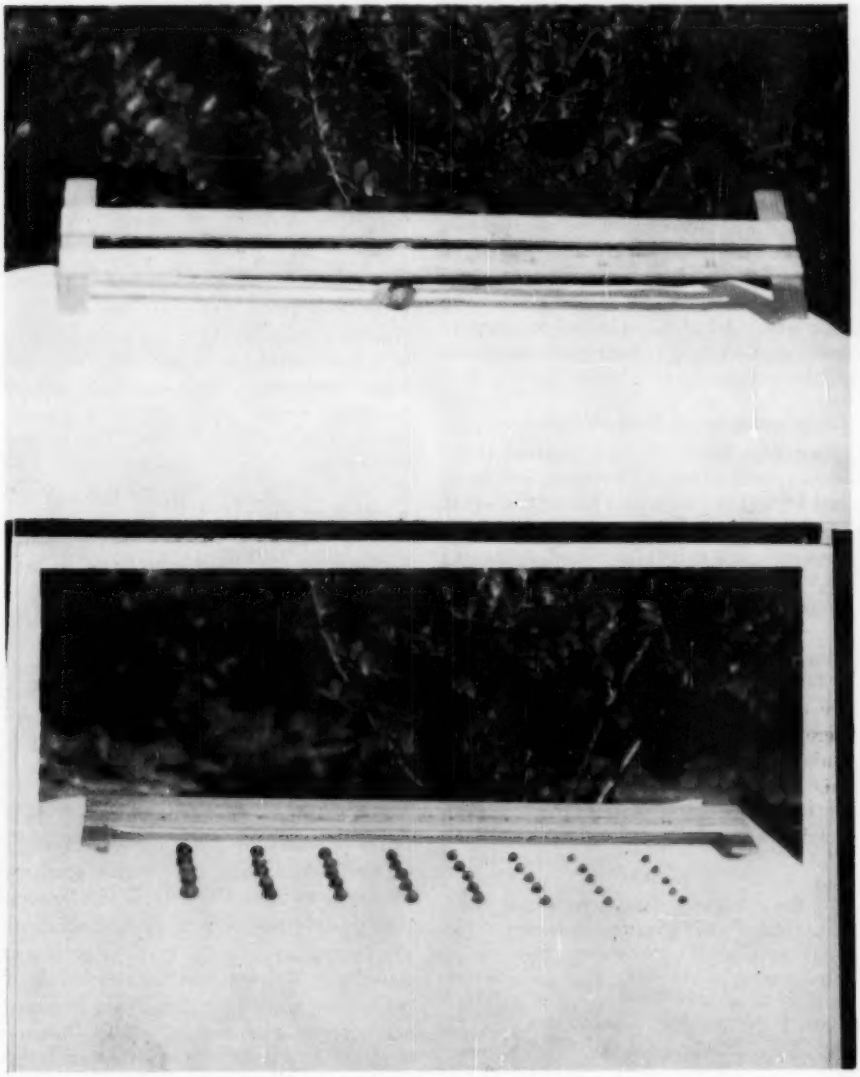

FIG. 2. Device used for sizing blueberries. Smallest berries shown are less than 11 mm. in diameter. Diameters increase 1 mm. every 2¼ inches, moving from right to left.

pended on the size of the berries. Thirty seconds was found to be sufficient for the smallest berries with an additional five seconds for each one millimeter increase in berry diameter. Leaving the berries in the blendor too long resulted in the skin being torn into small fragments which made separation of the seed difficult later on.

The acid content of the various samples was determined by neutralizing the diluted juice with a 0.2 N solution of sodium hydroxide, according to the methods specified in *Official Methods of Analysis*, A.O.A.C. (1). The percent total acid was calculated from the results of the titrations.

Determination of Seed Weight

After the acid and sugar content of the juice was determined the seed was separated from the skin and pulp by a series of decantings (pouring from a large beaker into a sieve) and finally washing into a cone of filter paper shaped into a funnel. This method has been used for many years and has now been recommended by Morrow, Darrow, and Scott (14). All of the mature seeds, most of the undeveloped ones and the placentas were recovered. The almost microscopic undeveloped seeds could not be saved by this method. The seed was dried in an electric oven for 48 hours at 50° C. and weighed immediately after removal. In determining the actual seed weight a correction had to be made for the placentas. Each berry contained ten placentas and the weight of these placentas was the same in all berries, regardless of size. It was, therefore, necesssary only to subtract the weight of 500 dried placenta from the gross weight of seed in each 50-berry sample to obtain the actual seed weight.

TABLE II

THE RELATIONSHIPS AMONG SEEDINESS, BERRY SIZE, SUGAR CONTENT AND ACIDITY

Size group	Average weight of berries in grams	Average percent soluble solids of berries	Average percent total acid of berries	Average seed weight per berry in grams
F	.69	10.5	3.61	.0185
E	.84	10.8	3.12	.0200
D	1.05	11.7	2.47	.0216
C	1.30	12.6	1.66	.0225
B	1.54	13.8	1.23	.0240
A	1.83	15.0	1.06	.0253

Results

Berry Size and Sugar Content

As seen from Table II, the data appear to show that there is a definite positive relationship between berry size and sugar content. The smallest berries (average weight per berry 0.69 grams) tested 10.5% soluble solids. The largest berries (average weight per berry 1.83 grams) tested 15.0% soluble solids. Upon close inspection of the data it can also be seen that percent soluble solids appreciably increased each time the berries tested were taken from the next larger size group. The berries of the largest size group averaged 165.2% larger (a little more than 2½ times larger) by weight than the berries of the smallest size group. The overall increase in percent soluble solids, between the smallest and largest size group, was 42.9%.

Seediness and Sugar Content

There was also a definite relationship between seediness and sugar content. From the data in Table II, it can be seen that the average percent soluble solids of the berries in size group F (size group containing the smallest amount of seed per berry) was 10.5%; whereas the average percent soluble solids of the berries in size group A (the size group containing the largest amount of seed per berry) was 15.0%. In every size group tested, the greater the amount of seed per berry, the greater was the average percent soluble solids. The overall increase in per-

TABLE III

THE RELATIONSHIPS AMONG BERRY SIZE, SUGAR CONTENT, ACIDITY AND SEEDINESS OF IMMATURE BERRIES

Size group	Average weight of berries in grams	Average percent soluble solids of berries	Average percent total acid of berries	Average seed weight per berry in grams
C	1.09	11.0	5.05	.0239
D	.99	10.8	4.87	.0213
E	.80	10.4	4.53	.0189
F	.64	10.2	4.60	.0168

cent soluble solids, moving from the least seedy to the seediest, was 42.9%.

Fertilizer Treatments and Sugar

The complete data for this portion of the problem is presented in Table V. The berries tested from the plots receiving the minor elements and the plots receiving nitrogen and phosphorous in combination were slightly sweeter than berries tested from the other plots. The average percent soluble solids for all the size groups of the minor element plots was 12.9%. The average percent soluble solids for all the size groups of the NP plots was slightly higher than 12.7%. Berries from the plots receiving N/2 and N treatments tested the lowest. The average percent soluble solids for all the size groups of the N/2 treatment plots was slightly less than 12.1%. The average percent soluble solids for all the size groups of the N plots was 11.9%. The average percent soluble solids for all the size groups of the other fertilizer test plots tested from 12.1% to slightly less than 12.7%.

Time of Picking and Sugar Content

The sugar content increased, in every size group, between the first and second picking (Table IV). The average percent soluble solids of the fruit of the first and second pickings was 12.4% and 14.2% respectively. However, in every size group, the sugar content went down between the second and third pickings. The average percent soluble solids of the berries of the third picking was 13.4%. In size group A the sugar content of the berries was even lower in the third picking (14.6% soluble solids) than in the first picking (15.2%). However, in all the other size groups the sugar content of the third picking still remained higher than the sugar content of the first picking.

Berry Size and Acidity

There was a definite negative relationship between berry size and acidity. The data for this relationship is presented in Table II. The smallest berries (average weight per berry was 0.69 grams) tested 3.61% total acid; whereas, the largest berries (average weight per berry was

TABLE IV

THE RELATIONSHIP BETWEEN TIME OF PICKING, SUGAR CONTENT, AND ACIDITY

Size group	Average weight per berry in grams			Average percent soluble solids of berries			Average percent total acid of berries		
	First pick	Second pick	Third pick	First pick	Second pick	Third pick	First pick	Second pick	Third pick
E	0.82	0.82	0.80	10.6	12.8	12.6	3.10	2.34	1.04
D	1.00	1.07	1.04	12.0	13.0	12.8	2.60	1.90	0.95
C	1.33	1.30	1.28	11.2	14.0	13.2	1.88	1.50	1.26
B	1.54	1.49	1.48	13.2	14.8	13.8	1.06	1.66	1.13
A	1.86	1.71	1.80	15.2	16.4	14.6	0.88	1.30	1.30
Mean	1.31	1.28	1.28	12.4	14.2	13.4	1.90	1.74	1.14

1.83 grams) tested 1.06% total acid. Upon closer inspection of the data it can be seen that the percent total acid decreased appreciably each time the berries tested were taken from the next larger size group. The overall decrease in percent total acid, moving from the smallest to the largest berries, was 70.6%.

Seediness and Acidity

A definite negative relationship was also found to exist between seediness and acidity (Table II). The berries containing the smallest amount of seed tested 3.61% total acids; whereas, those containing the largest amount of seeds tested 1.06% total acids. There was an appreciable decrease in percent total acids each time the berries tested were selected from the next seediest group. Going from the least seedy to the seediest berries, the overall decrease in percent total acid was 70.6%.

Fertilizer Treatments and Acidity

On the basis of the data presented in Table V, samples from the plots receiving nitrogen (N) and the plots receiving both nitrogen and sulphur (NS) were considerably more acid than those from the other fertilizer plots. The average percent total acids for all the size groups of the (N) plots and (NS) plots was 2.49%, and 2.52%, respectively. The

TABLE V

THE EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON SUGAR CONTENT AND ACIDITY

Fertilizer treatments	Size group						
	F	E	D	C	B	A	Mean
			Average weight per berry in gm.				
Minor	.74	.90	1.10	1.35	1.56	1.79	——
Urea	——	.84	1.02	1.26	1.50	1.78	——
N/2	——	.79	1.04	1.26	1.50	1.92	——
N	.74	.86	1.06	1.37	1.61	1.82	——
2N	.77	.88	1.12	1.35	1.60	1.87	——
NS	——	.84	1.03	1.30	1.51	1.87	——
NP	.61	.80	1.04	1.27	1.54	——	——
NPK	——	.85	1.04	1.33	1.57	1.81	——
NPKS	.73	.86	1.11	1.36	1.58	1.77	——
			Average percent soluble solids				
Minor	11.1	11.0	12.3	13.6	14.7	15.0	12.9
Urea	——	11.0	11.7	12.6	13.4	14.8	12.7 –
N/2	——	10.5	10.9	11.7	12.9	14.4	12.1 –
N	10.0	9.8	11.5	12.7	12.7	14.9	11.9
2N	10.8	10.9	11.7	13.1	14.5	14.2	12.5
NS	——	10.9	11.3	11.9	13.6	15.4	12.6 –
NP	11.0	11.2	12.6	13.8	14.8	——	12.7 +
NPK	——	10.7	11.6	12.0	13.4	15.0	12.5 –
NPKS	10.0	10.9	11.2	12.0	13.7	14.7	12.1
			Average percent total acids				
Minor	3.27	2.54	1.42	1.22	1.17	——	1.92 –
Urea	——	3.03	2.63	1.80	1.21	.89	1.91 +
N/2	——	——	——	——	——	——	——
N	4.26	3.50	2.82	1.94	1.45	.96	2.49
2N	3.68	2.93	1.99	1.40	1.17	——	2.23 –
NS	——	4.11	3.15	2.29	1.57	1.47	2.52 +
NP	——	——	——	——	——	——	——
NPK	——	2.87	2.52	1.46	1.02	1.07	1.79 +
NPKS	3.24	2.74	2.16	1.34	1.05	——	2.11 –

berries from the plots receiving nitrogen, phosphorus and potassium (NPK) and the minor elements (minor) tested the lowest; a little higher than 0.79% in the former treatment and a little lower than 1.92% in the latter. The average percent total acids of the berries from all the other fertilizer test plots were slightly lower than 2.23%.

Time of Picking and Acidity

The influence of time of picking on acidity, as noted in Table IV, was quite pronounced. The acidity of the berries decreased between the first and second pickings and also between the second and third pickings. The average percent total acids of the fruits of the first, second and third pickings was 1.90%, 1.74% and 1.14% respectively. On an individual size group basis, in sizes C, D, and E, the acidity decreased between the first and second pickings; whereas, in the two largest size groups, sizes A and B, the acidity increased. There was a considerable decrease in the acidity of the fruit between the second and third pickings. In the two smallest size groups (D and E) the acidity of the berries of the third picking was half that of the berries of the second picking. Contrasting with this was the fact that in the largest size group (A) the percent total acid did not change between the second and third pickings.

Berry Size and Seediness

There definitely appears to be a positive relationship between berry size and seediness (Table II). The average seed weight per berry of size group F (the smallest size group tested) was 0.0185 grams; whereas, the average seed weight per berry of size group A (the size group containing the largest berries) was 0.0253 grams.

In every plot tested, the larger the fruit, the greater was the average seed weight per berry. The overall increase in average seed weight per berry (going from the smallest to the largest size group) was 36.8%.

Discussion and Conclusions

Factors Affecting the Sugar Content

Size of Fruit. The results rather strongly indicate that the larger berries are the sweetest. This positive relationship between size and sugar content was quite pronounced. Similar results were obtained in every test. It is interesting to note that this relationship between size and sugar content also held true even when immature fruit was tested. A sample of berries still showing a faint tinge of red through the overall blue color was divided into four size groups. These groups were tested for percent soluble solids and percent total acid, and showed the same sugar-size relationship as was found to exist in the mature fruit.

In endeavoring to explain this relationship between berry size and sugar content, it should be pointed out that under the present methods of harvesting blueberries, where berries are picked by running the fingers lightly through the clusters and gathering those that fall, there is a possibility that in a box of fruit there might exist quite a range of maturity among the individual berries. If this difference does exist, perhaps the larger are more mature than are the smaller ones. Their advanced state of maturity might account for their testing higher for sugar. However, this relationship between size and sugar content was true for immature fruit and it was true for fruit of the first, second and third pickings. This would indicate, then that the size-sugar relationship is independent of the maturity of the fruit.

Seediness. There also existed a positive relationship between seediness and sugar content. This was to be expected, since there also existed a positive relationship between size and seediness. The increase in average seed weight as the

berries increased in size can be explained by the larger number of fully developed seeds in the larger berries as opposed to a greater number of undeveloped seeds in the smaller berries. These results, therefore, demonstrate that large size in blueberries is dependent on the maturing of the many ovules contained in the fruit. The development of sugar content in blueberries follows the completed development of the fruit, viz., the development of seeds. It was observed that the largest berries were found to be seediest in immature as well as mature fruit.

Fertilizers. The various fertilizer treatments did not seem to significantly effect the sugar content of the berries. These results parallel most of the results obtained by other investigators working with strawberries and grapes. Some experiments indicated that potassium increases the sugar content slightly. However, the results obtained in this study did not indicate any relationship between potassium and sugar content.

Shoemaker and Greene (17), working with strawberries, noticed that berries receiving lower nitrogen treatments resulted in a very slightly increase in percent soluble solids. Again there was nothing in the results of the present study to indicate such correlation. It is interesting to note, however, that the plot receiving no nitrogen, but minor elements instead, tested higher than any other fertilizer plots for percent soluble solids. The berries taken from the same plot also tested low in percent total acid. This relationship could result from the absence of nitrogen in the treatment or the effects of one or more of the minor elements. However, the plots receiving nitrogen and phosphorus in combination also tested higher for sugar content.

It is felt that the data on the fertilizer effects are too incomplete and the number of replications insufficient for one to draw any definite conclusions. It is believed that this problem should be isolated and given more extensive and careful study.

Time of Picking. The results obtained from this study seem to indicate that the sugar content of blueberries is affected by the time of picking, despite the fact that the percent soluble solids decreased between the second and third picking. It was indeed unfortunate that the test was interrupted by the abnormally cool weather the week before the third picking. There is no doubt that this cool weather prevented the berries from developing more sugar. It would be best, therefore, to disregard the data on sugar content obtained during the third picking. Nevertheless, the results do show the effect of weather on sugar development in berries. There was, however, a definite rise in sugar content in every size group between the first and second picking. One, therefore, might assume that there is a trend in the direction of a relationship between sugar content and time of picking. It is probable that if the weather had been normal the sugar content would have continued to rise. It seems reasonable to expect that the berries left on the bush have a better chance to come nearer to reaching the maximum possible sugar content.

Factors Affecting the Acidity

Size. As there was a direct relationship between size and sugar content, there was an inverse relationship between size and acidity. The explanation is similar to that for maturity of the fruit discussed under " Factors Affecting the Sugar Content ". However, there is one difference. When immature berries were tested, the larger beries were slightly more acid than the smaller ones (Table III). If more extensive research is undertaken with regards to sugar–size relationship it would be well to cover the acid–size relationships at the same time.

Seediness. Seediness and acidity are inversely related. The berries with the

most developed seeds were the least acid. This might be explained on the theory that the development of seeds is related to the complete development of the fruit. The results indicated, as mentioned earlier, that complete development results in larger fruit, and, in every case the larger the fruit the lower the acidity.

Fertilizer Treatments. The explanation of the relation between minor elements and low percentage of total acid is not known. (See p. 340). It was suggested that the relationship between minor elements and sugar content was worthy of further research. It would be logical, of course, to include the minor elements—acidity relationship as well, in these experiments. There is one more significant point that can be made with regards to the effects of the various fertilizer treatments on the percent total acid of blueberries. In the case of the plots receiving elemental sulphur combined with nitrogen (NS), the acidity of the berries was considerably higher than in any other fertilizer test plots. Though this fertilizer treatment did not affect the sugar content of the berries, the influence on the acidity was quite pronounced. When sulphur was added in combination with potassium, phosphorus and nitrogen, however, there was no change in acidity. The results with sulphur demonstrate a need for further experimentation. It was also noted that the plots receiving the treatment of minor elements tested rather low for acidity. This is interesting in view of the fact that the minor plots tested rather high for sugar.

Time of Picking. Time of picking also affected the acidity of blueberries. Between the first and second pickings the average percent total acid of all the size groups decreased considerably. The percent total acid decreased in every size group except the two largest sizes (A and B). This deviation cannot be accounted for except in size group A where there was a decrease in the average weight per berry between the first and second pickings. It has been suggested earlier that there is a relationship between size and acidity which could account for the relationship increase in acidity.

The average percent total acid of all the size groups tested also decreased considerably between the second and third pickings. This decrease in succeeding pickings was greatest with the smallest sizes (D and E). This seems to indicate that perhaps the chemical breakdown of acids in the larger berries occurs earlier and faster; whereas, with the small fruit, later and slower. The abnormal weather conditions prior to the third picking did not seem to affect the acidity of the berries.

Because of the manner in which the blueberry plots are laid out at the Lewis Brown Farm, there are no suitable replications. It is not possible, therefore, to establish the significance of the results statistically. The results are so striking, however, that it is apparent from casual observation of the data that a high degree of correlation exists between berry size and sugar content, acidity, and seediness. It was possible, however, to obtain correlations from the data presented in Table II. The correlations obtained, based on averages, demonstrate rather markedly the definite relationship existing between size and sugar content, acidity, and seediness. The coefficients of correlation were as follows:

1. Between size and average percent soluble solids—0.98.
2. Between size and average percent total acid—minus 0.98.
3. Between size and average seed weight per berry—0.99.

Recommendations

From these experiments, it was found that larger berries are sweeter and less acid than are the smaller ones. It might possibly be advantageous, therefore, for some growers to sort berries into two

sizes. The larger sizes, which would have a higher sugar content, could be sold fresh and the smaller sizes, which would be more acid, could go to the processors. Fresh fruit consumers are definitely attracted to the large berries and prefer the sweeter berries. Processors are not so much concerned with size but do prefer the more acid berries. This might be one way to please the processors and at the same time increase the popularity of the blueberry as a fresh fruit. Growers might even receive a premium for large, uniform berries when sold for fresh consumption.

Sizing the fruit would be relatively easy and would only necessitate an extra step in handling. The berries could be picked in bulk in the field and gently shaken through a sieve that would separate them into two sizes. The berries for the fresh market could then be placed in the usual pint baskets and the berries for processing packed in suitably larger containers.

Summary of Results

1. There is a definite positive relationship between berry size and sugar content. In every plot examined the larger berries consistently tested higher for percent soluble solids. The overall increase in percent soluble solids, between the smallest and largest berries, was 42.9%.

2. A definite relationship exists between berry size and acidity. In every plot tested the larger berries consistently tested lower for percent total acid. The overall difference in percent total acid, between the smallest and largest berries, was 70.6%.

3. The more seeds a Jersey blueberry contains the larger it is. In every test the larger berries were the seediest. The overall increase in average seed weight per berry, going from the smallest to the largest size group, was 36.8%.

4. The various fertilizer treatments did not influence significantly the sugar content of the berries. However, berries selected from plots receiving the minor elements and nitrogen and phosphorus in combination did test slightly higher for sugar content than berries selected from any of the other fertilizer plots. Berries selected from plots receiving half-nitrogen (N/2) tested slightly lower than the rest.

5. There were no significant degree of relations between any of the fertilizer treatments and acidity except where berries were selected from the plots receiving nitrogen and sulphur in combination. These berries tested considerably higher for acidity than the berries selected from any of the other fertilizer plots. The berries from the plots receiving the treatment containing the minor elements and nitrogen, phosphorus and potassium in combination tested the lowest.

6. The data dealing with the influence of time of picking on sugar content was incomplete. The results, notwithstanding, did indicate a trend towards berries harvested late in the season being sweeter.

7. The berries picked towards the end of the season were less acid than those picked at the beginning of the season.

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Ginseng

Although there is no known medicinal value in ginseng, there is a continuing demand for the root. Two species of Panax *are acceptable sources, one Asiatic, the other North American. As a crop, ginseng is no gold mine, but may give a reasonable return to growers willing to wait the five to seven years required for maturation.*

LOUIS O. WILLIAMS[1]

Ginseng root, much sought after by the Chinese as a panacea for most of the ills to which the flesh is heir, has attracted special attention during the last year or so due to the high price of the root. The United States Department of Agriculture received during the fiscal year 1956–1957 more than 5,800 requests for the now unavailable, Farmers' Bulletin #1184, Ginseng Culture, an indication of this interest.

There are two species of *Panax* which are accepted as ginseng, *Panax ginseng* C. A. Mey., an Asiatic species collected from the wild and cultivated in Japan and Korea, and *Panax quinquefolius* L., native of North America. American ginseng has apparently been collected from wild plants and exported to China since the early 1700's. The first shipments of ginseng from the colonies went either by way of France or England, then to the Orient. There is a record that a ship or sloop, " Hingham ", sailed from Boston for China with 55 tons of gingseng in 1773. The first shipment of ginseng direct to China after the Revolution is said to have been made by John Jacob Astor from New York in 1782. The root from that shipment was reported to have brought $3.00 a pound. Ginseng is given as the principal cargo of the American ship Empress of China, which sailed for China on February 22, 1784.

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Export of ginseng continued through the years. Records kept by the Bureau of Statistics of the U. S. Treasury Department for the years 1858 to 1896 indicate that there was a continuing demand for the root. During the years mentioned, the smallest amount was shipped in 1859, 110,429 pounds, and the greatest amount was shipped in 1862, 622,761 pounds. The price range during this same period was from 49 cents to $3.86 a pound. The total amount of root shipped during the period was 13,738,415 pounds.

The cultivation of ginseng seems to have begun in the 1870's by Abraham Whisman, at a place then called Boones Path, Virginia. Between that time and 1895, there were about twenty ginseng gardens started.

In 1895, the U. S. Department of Agriculture published a bulletin (No. 16) entitled " American Ginseng, Its Commercial History, Protection, and Cultivation ". The request for the bulletin was great enough to require the revision and printing of a new edition in 1898. In 1902, this bulletin was again reprinted with the addition of a " Note of Warning " signed by Frederick V. Coville calling attention to a " boom " in sale of ginseng seeds and roots " based on extravagant, and in some cases, fraudulent representation ".

During the same period, bulletins on ginseng culture were published by state experiment stations in Pennsylvania,

FIG. 1. A plant of American ginseng, *Panax quinquefolius*.

FIG. 2. *Panax ginseng* C. A. Mey. Asiatic ginseng from Manchuria. This specimen was said to have been worth $206 in 1914. It was the property of Mr. C. J. Medzikovsky, Commercial Attache of the then Imperial Russian Embassy in Washington. Photo credit: New Crops Research Branch, U. S. Department of Agriculture.

Kentucky, New York and possibly elsewhere. Newspapers and magazines carried stories (and extravagant advertisements) on gingseng. Stock companies were formed to grow ginseng on a large scale. It is likely that hundreds of small gardens were started.

A reaction began to take place about 1903 or 1904 against the extravagant claims made, that a fortune was to be had for the taking. Alternaria blight became prevalent in 1904 and caused great damage in the crop and is said to have discouraged thousands of growers.

The collection and cultivation of ginseng continued through the following years up to the time of World War II, on a somewhat reduced scale. During the years between the two World Wars, the price of root fluctuated between $3.62 (in 1933) and $9.24 (in 1930) a pound. During World War II, there was almost no export of ginseng root, but after the war, exports were made again. The export reached 185,876 pounds in 1946 but a downward trend started in 1947 and in 1951 only 76,999 pounds were shipped. Recently the export has been a little more than 100,000 pounds a year.

The market price of root has been increasing and in mid-1957 it reached an all time high of $24.00 a pound for wild root. The market price of cultivated root is about 60 percent of comparable grades of wild root.

Most of the world production of ginseng is sent to those parts of the world where there are large Chinese populations. Hong Kong is now the principal market for the root and supplies go there from Japan, Canada, the United States, and Korea, with small amounts from Communist China and other sources. Ginseng is then re-exported from Hong Kong to most countries of Southeast Asia and Malasia.

The market price paid for ginseng to growers or collectors is a relatively small part of the cost of root to the ultimate consumer. Ginseng is reported to have sold for more than $130.00 a pound in wholesale lots in Hong Kong in 1951. Canadian and American root cost $17.57 a pound that year. What a consumer in

Singapore or Saigon may have paid for a fraction of an ounce of gingseng must have limited use of the root to the relatively well-to-do.

The generic name for ginseng, *Panax*, is derived from the Greek *PAS* and *AKOS*, *all* and *cure*, or a panacea. The Chinese from time immemorial have considered ginseng to be a cure for most diseases. There seems to be no scientific basis for that belief. Dr. Heber W. Youngken in the most recent edition of his "Textbook of Pharmacognosy" (1948) says only that "Ginseng is used by the laity as a stimulant and aromatic bitter. Chinese also employ it as an aphrodisiac and heart tonic but without scientific justification".

The grading of ginseng is a highly subjective art. Color, weight, taste, condition, age, appearance, source, and shape are all taken into consideration. A root shaped like a man would demand a premium even though all other characteristics of the root were only moderately good or even poor. The grades of ginseng probably run into the hundreds, most of them meaningless. For a product that has no proven value as a food, drug, of for other use, it is somewhat surprising that there has been and continues to be a constant demand for it.

Ginseng cultivation in the United States is carried out by a relatively small number of growers. The largest acreage of a single grower is that of Fromm Brothers, Inc., Hamburg, Wisconsin, who have about 100 acres under cultivation.

There is a question in regard to the size of the potential market for ginseng. Ginseng is decidedly a luxury item and it is questionable whether or not the market will absorb much more than the present world production. The New York market for ginseng went to $24.00 a pound in mid-1957 but dropped off about 20 percent as a result of reports of a crop 10 to 15 percent larger than expected. Collectors and small dealers withheld their root and by the end of September, the price had returned to $20.00 a pound.

The potentialities of ginseng as a crop in America depend on a number of variables. The first consideration is the size

FIG. 3. *Panax ginseng* C. A. Mey. A panoramic view of a ginseng plantation near Koryoho, Korea. Taken in 1929. Photo credit: New Crops Research Branch, U. S. Department of Agriculture.

of the world market and the amount of root that the market can absorb without the price falling to the point where it is no longer profitable to collect or cultivate it. It seems that a relatively small increase in total production may have a relatively great effect on market price, for the present price is based on demand and supply and it is probable that the demand is not now much greater than the supply. Secondly, ginseng is decidedly a luxury item and economic recession in the areas where it is consumed will decrease the demand. Third, ginseng is cultivated in Japan and Korea, but nothing is known concerning any increase in acreage which may have taken place there in the last year or two. Fourth, the crop is not a gold mine and should not be grown with the idea that the return will be relatively great for the time, effort, and capital expended. It is assumed, however, that reasonable profits can be made on cultivation of ginseng by growers who are good plantsmen and are willing to care for the plants for the five to seven years that are required to mature a crop from seeds.

Utilization Abstract

Horseradish. About one-third of the horseradish (*Armoracia lapathifolia*) used in the United States is grown on more than 500 acres near Eau Claire, Wisconsin. Other producers are near East St. Louis, Chicago, and in New Jersey. Horseradish is propagated by cuttings, and planting and harvesting are done in both spring and fall. The crop requires a deep, highly organic soil and is frequently cultivated and heavily fertilized. The roots weigh up to several pounds, and a good yield is 600 pounds per acre. In harvesting, specially designed diggers go eighteen inches deep and dump the roots onto the surface. The roots are topped and hauled to storage at 32° F. For processing, they are taken from storage washed for two to four hours in a churn-like washer, and then grated. From the grater, the horseradish goes to the mixer where cream, vinegar, salt, sugar, and other seasonings may be added. After the finished mixtures are bottled, they are shipped in refrigerated cars or trucks. Pure horseradish, after grating, soon darkens and loses its pungency. The addition of vinegar to grated horseradish preserves the color and strength somewhat, and refrigeration will delay deterioration still more, but not enough to permit shipping for any distance. The addition of cream to the product extends its keeping period from days to months. The pungency of horseradish is due to a highly volatile oil similar to that of mustard seed. Horseradish is usually used as a condiment with meats, especially beef, but can also be used to flavor vegetables. (*Anon., The Farm Quarterly 11*(*4*): *66–67, 84–85. 1957.*)

JOHN W. THIERET

Tropical and Subtropical Fruits in Florida (*Other Than Citrus*)

Avocado and mango are the leading commercial fruits of South Florida. Lychee, guava, pineapple, bananas, papayas, and persimmon, are of minor economic value, while sapodilla, macadamia nut, Barbados cherry and the Mysore black raspberry show promise of commercial development. All of these fruits and many more are grown as dooryard plants. The fact that such a large number of tropical and subtropical fruits can be grown in South Florida has made the subject of tropical pomology a very important one for this area.

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The southern half of the Florida Peninsula is fortunate in possessing a climate which is favorable for growing a large number of species of tropical and subtropical fruit plants. Indeed, there is probably no other area where so many different kinds of fruit plants have been brought together from countries all over the world.

The rainfall in peninsular Florida is generally adequate for most tropical and subtropical plants, ranging from 45 to 65 inches a year. About two-thirds of the rain occurs between June and October with the rest of the year being relatively dry. This alternation of dry and wet seasons is suitable for such plants as the mango and lychee.

The limiting factor in growing tropical and subtropical fruits in Florida is the minimum temperature. It is true that due to its southern location and the warming influence of the Gulf Stream on the east and the Gulf of Mexico on the west, South Florida is spared the damaging effects of many of the cold waves that sweep down into Florida from the northwest. Nevertheless, no part of the State, except Key West, where official weather stations are located has been free of frost. Severe cold spells have occurred with temperatures below freezing lasting for several hours. The last freeze that did appreciable damage was in 1940, but the cold spell of January, 1956, also injured many plants. Cold spells occur every year but the temperature rarely reaches freezing and then only for a few hours just before dawn. Young plants may be killed and older plants may be injured, but the latter will recover and young plants can be protected with heaters, wrapping the trunks with straw, and other measures. Many tropical plants will, if dormant and not in a flush of active growth, tolerate temperatures to 33 or below, if of short duration. The proximity to large bodies of water will help to keep the temperature from reaching the freezing point. Therefore, plantings along the coast, southward from Merritt Island on the east and St. Petersburg on the west, and inland along lake shores, are recommended in order to minimize the danger of injury from cold.

History

The Spaniards established several missions along the coast of Florida in the 16th Century and have been credited with the introduction of such fruit plants as grape, pomegranate, orange, fig, olive,

lemon, plantains, pineapple, papaya, guava, shaddock and possibly the coconut (6). In the late 1700's and early 1800's, individuals from the Bahama Islands settling on the Florida Keys and Key West brought in such plants as the sapodilla and Spanish lime.

The first attempt to introduce fruit plants on a large scale was made by Dr. Henry Perrine (16, 17). Perrine was stationed in Campeche, Yucatan, as a U. S. Consul from 1827 to 1837 and thus had the opportunity to observe plant products, especially fruit plants, of the tropics. He wrote many letters to the U. S. Congress urging the establishment of a plant introduction garden in Florida and in 1838 Congress passed an act granting Perrine a township in South Florida for propagating and cultivating tropical plants. Perrine arrived in Florida in 1838 and settled on Indian Key. Here, as well as on nearby Matecumbe Key, he established his nursery and began to propagate the economic plants which he had previously sent from Yucatan. Perrine's efforts ended in failure when in 1840 he was massacred by the Calusa Indians and his home and nearly all of his plants were destroyed. The sisal, which has become well established on the Florida Keys, and possibly the Mexican or Key lime are thought to be his introductions. He may also have been instrumental in starting pineapple culture on the Florida Keys and it is thought that he introduced the date palm to Florida.

From 1840 to 1880 individuals who settled in the southern part of Florida brought in such tropical fruit plants as the mango and avocado (15). Others, like General H. S. Sanford in Central Florida, were active in establishing tropical fruits in Florida (20). General Sanford, world traveler and one time minister to Belgium, came to Florida in 1869. Because of his numerous contacts in Central and South America and Africa, he was able to obtain and import plants and seeds of many tropical and subtropical fruits and ornamentals. The list of plants which he had established included mangos, avocados, guavas, macadamia, and the lychee, the latter fruiting during the 1870's. Most of his plants were killed during the freeze of 1886.

The first successful attempt to introduce tropical and subtropical fruit plants was by Pliny and Egbert Reasoner of the Royal Palm Nursery at Oneco on the west coast of Florida (15, 23). Pliny W. Reasoner founded the nursery in 1881 and his brother Egbert N. joined him in 1885. Pliny died in 1888 of yellow fever but his work was carried on by his brother and the nursery continued to be active until it was sold by R. P. Reasoner in the 1920's. Pliny and Egbert contributed to horticultural journals and wrote mostly on exotic plants suitable for South Florida. By 1887 seeds and plants were being imported from all over the world and many of the plants in Florida, the Gulf States, and southern California owe their introduction to the Reasoner brothers. The Royal Palm Nursery issued a catalogue from 1887 to 1930.

In 1888 the newly established Division of Pomology of the U. S. Department of Agriculture published Bulletin No. 1, "Report on the condition of cultivated tropical and semi-tropical fruits in Florida and the Gulf States in 1887". It was written by Pliny Reasoner and contains much valuable information on early introductions and plants previously introduced and grown in Florida (15). Over 50 species were described and discussed.

1888 was also the date when the Florida State Horticultural Society, one of the oldest in this country, was founded. The Proceedings of the Society were first published in 1892 and have appeared every year since then. The early num-

FIG. 1. *Antidesma bunius*, bignay. The fruit, produced in currant-like clusters, can be used for jelly, juice, or wine. The trees produce heavy crops.

bers contain valuable information on history of the development of horticulture in Florida and the current numbers contain up to date information on work being done in this state. In 1933 the Krome Memorial Section was created, honoring Mr. William Krome, a pioneer horticulturist in South Florida. This

section deals with tropical and subtropical fruit other than citrus.

Dr. David Fairchild (1869–1954) organized the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry in 1898. Through his efforts many fruit plants were introduced and grown at the Plant Introduction Garden in Miami (1898 to 1914), Buena Vista (1914 to 1922) and Chapman Field (from 1922 to the present). Dr. Fairchild made many expeditions throughout the world exploring and introducing new plants. He was well known for his enthusiasm for tropical fruits and he wrote three books on his experiences. Fairchild Tropical Garden was named in his honor and his home, the Kampong, in Coconut Grove, was a mecca for horticulturists for many years.

Wilson Popenoe, one of the BPI explorers, was stationed in Miami for many years and he explored many countries of Central and South America searching for fruit plants. He wrote the first textbook dealing with tropical fruits, "Manual of Tropical and Subtropical Fruits", published in 1920 (14). It is still widely used and quoted as a standard work on this group of plants.

The University of Florida established the Sub-Tropical Experiment Station in 1930 at Homestead to work on vegetables and tropical fruits. The Station consists of 120 acres and two vegetable farms and work is done on the development of new and improved varieties, general culture, disease and insect control, of such fruits as the avocado, mango, sapodilla, lychee, papaya, lime, guava, Barbados cherry, and may other fruit plants. The first edition of "Miscellaneous Florida Tropical and Subtropical Fruits" was published in 1931 and has been revised in 1938, 1941, and 1953 (11). It is the standard work for Florida. Other Bulletins have been published on papaya (38, 82), lychee (27), avocado (81), sapodilla (63), guava (64), and mango (66).

The University of Miami Experimental Farm was founded in 1948 to work on the commercial production of lime, avocado, mango, guava, and lychee. The University of Miami Food Research Laboratory has experimented with the processing of tropical fruits.

Present Status

Of all the fruit plants grown in Florida at the present time, only the avocado and mango have become commercial fruits and planted on a large scale. Other fruits such as the lychee, guava, pineapple, banana, papaya, and persimmon, are of minor economic value but nevertheless are grown commercially. The sapodilla, macadamia nut, and Barbados cherry are promising commercial fruits. Many of the other fruits, such as the tropical black rasberry, are grown on a small scale and fruits are sold locally or used to make jellies and jams. All those named above, as well as all the other fruit plants in Florida, are grown as dooryard plants. The homeowner in Florida, with a large number of plants available for growing as backyard fruit plants (7, 9, 24), has a great interest in tropical pomology and it is his interest that keeps this subject alive and stimulates the never ending search for better varieties. The establishment of the Rare Fruit Council (21, 22) is an example of the interest that has developed in Florida in tropical fruits.

Many nurseries still propagate most of the fruit plants from seed and since considerable variation takes place in these seedlings inferior plants often result. So the problem today is to find superior types and to promote vegetative propagation. This is accomplished by breeding or seedling selection. Some of the better guava varieties have been developed by hybridizing, but many of the improved tropical fruits have been developed by seedling selection. Many plants existing in back yards will often

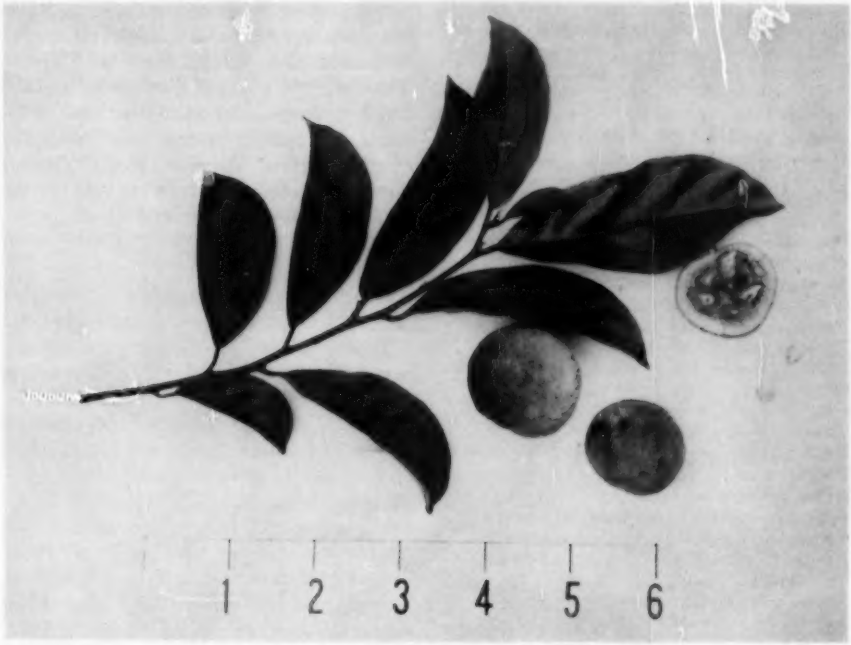

FIG. 2. *Artocarpus hypargyrea*, kwai muk, recently introduced from Hong Kong. The fruits are like miniature jakfruits.

produce fruit of superior quality. Also, there are superior varieties of many of these fruit plants in other countries throughout the world that should be tried in Florida. But whether by hybridizing, seedling selection, or importing propagating material from other countries, the important thing is to produce plants that are disease resistant and productive, bear attractive fruit of excellent quality and high food value, that can be marketed successfully. These will be the improved clones that can be propagated vegetatively and be much superior to average seedlings.

The discussion that follows describes briefly the tropical and subtropical fruits, other than citrus, that are being grown in South and Central Florida. After the discussions of most of the species, references are given to one or more publications in Florida or elsewhere in which further information may be obtained. On page 372 is an annotated check list, arranged according to family, of these plants in which the scientific name, common name, and native country or area are given.

Five of the plants are native to Florida—*Annona glabra, Chrysobalanus icaco, Coccoloba uvifera, Diospyros virginiana* var. *Moisieri*, and possibly *Cocos nucifera*. All others have been introduced from foreign countries. Missing from this list are numerous species that have at one time or another been classified as having edible fruit, but, in the opinion of many, produce fruit that is inferior and not especially desirable. These plants are the following:

Adansonia digitata L., baobab
Aegle marmelos Correa, bael fruit

Britoa acida Berg., para guava
Byrsonima crassifolia HBK, nance
Casasia clusiaefolia Urb., seven-year apple
Cecropia palmata Willd., and *C. peltata* L., snakewood
Dillenia indica L., dillenia
Eugenia curranii C. B. Rob., lipote
Garcinia dulcis Kurtz.
Garcinia tinctoria W. S. Wight
Garcinia spicata Hook. f.
Grewia asiatica L., phalsa
Hovenia dulcis Thunb., Japanese raisin tree
Malacantha warneckeana Engler
Morinda citrifolia L., limburger tree
Nauclea esculenta Merr., Guinea peach
Pleiogynium solandri Engl., Burdekin plum
Psidium araca Raddi, Brazilian guava
Psidium friedrichsthalianum Nied., Costa Rican guava
Psidium molle Bertol, sour guisaro
Randia formosa Sch., Randia
Rheedia macrophylla Planch
Rollinia mucosa Bail.
Rubus rosaefolius Smith
Strychnos spinosa Lam., Natal orange
Terminalia catappa L., tropical almond
Vangueria madagascariensis J. F. Gmel., Voavanga
Ximenia americana L., tallowood plum

Some fruits are grown in Florida as ornamental plants only and rarely if ever can be successfully fruited. These are the olive, *Olea europea* L., date palm, *Phoenix dactylifera* L., and pomegranate *Punica granatum* L. The pistachio, *Pistacia vera* L., and Chinese jujube, *Zizyphus jujuba* Mill., have not been grown successfully. All of these fruits do better in a Mediterranean type of climate, such as prevails in California.

Certain well known tropical fruits that have not as yet been grown successfully in Florida are not discussed here. These are strictly tropical species that do not tolerate cold weather or the dry period during winter and spring. These species are the following: Brazil nut, *Bertholletia excelsa* Humb.; Gandaria, *Bouea macrophylla;* durian, *Durio zibethinus* Merr.; mangosteen, *Garcinia mangostana* L.; langsat, *Lansium domesticum* Jack; rambutan, *Nephelium lappaceum* L.; pulasan, *Nephelium mutabile* Bl.; and santol, *Sandoricum indicum* Cav.

A few recently introduced species have not been grown for a sufficient time to determine their adaptability to Florida. These are the pili nut, *Canarium ovatum* Engler; Java almond, *Canarium commune* L.; genip, *Genipa americana* L.; abiu, *Pouteria caimito* Redlk; imbu, *Spondias tuberosa* Arrunda; and green sapote, *Calocarpum viride* Pittier.

Florida Fruits

Achras zapota L., sapodilla, is a popular shade and fruit tree for home gardens. A few small commercial plantings have been made, the fruit being sold in cities with large Spanish population. Many of the trees in dooryards are of seedling origin and usually produce small crops of fruit of indifferent quality. Two selections, however, have been made. One of these has been named Prolific and was one of many trees set out in a windbreak formation at the Sub-Tropical Experiment Station in 1936. In 1941 this tree bore a heavy crop and the fruit was of good quality. It was propagated by veneer grafting and a number of plants were set in the field in 1943. This variety has consistently produced good crops every year; the quality is good, the size medium-large, and the grafted trees bear at an early age. The other variety has been named the Russell; it originated as a seedling tree on the Florida Keys. It is of interest because of its good quality and large size, but the grafted trees are slower to bear and they produce fewer fruit than the Prolific. Six other selections have been made and are under study. The sapodilla fruit is eaten fresh or frozen, and it can also be used to make sherbets and ice cream. (63)

Anacardium occidentale L., cashew, is a rare plant in South Florida, its rarity being due mainly to its sensitivity to cold weather. Trees are grown most successfully near the coast in protected areas where they are able to obtain some size and bear good crops every year. Se-

lections have not been made and propagation is from seed. Both the red and yellow fruited types are represented in Florida. The fruit is eaten fresh and the fleshy apple-like part can be made into an ade, preserves, wine and pie. The nuts must be roasted to remove the caustic oil. (11)

Ananas comosus Merr., pineapple, was once an important commercial crop in Florida. From 1860 to shortly before World War I the pineapple was grown from Merritt Island along the coast south to and including the Florida Keys. On the west coast of Florida many acres were under slat shade. In 1908–09 it was estimated that there were 5,000 acres in production on the east coast and 1,110,547 crates were harvested. Competition from Cuba, presence of root-knot nematode (known as "Red Wilt"), lack of understanding of several mineral deficiencies, the freeze of 1917, and other factors, contributed to the decline of the pineapple industry in Florida. In recent years, however, a renewed interest has developed and there are small plantings in the vicinity of Sebring, Ft. Pierce, and Miami. The Red Spanish pineapple was and still is the principal variety grown. Other varieties include the Smooth Cayenne, Abakka, the Queen, Natal queen, Pernambuco, Sugar loaf, Egyptian queen, Cabezona, Congo, and Golden queen. (59)

FIG. 3. *Blighia sapida*, akee. An attractive fruit, the aril being the edible part. It is poisonous in the unopened fruit; the black seeds are poisonous at all times.

Annona.—There are a number of species of Annona grown as dooryard fruit plants in South Florida. The sugar apple, *A. squamosa* L., has been most successful. The fruit is eaten fresh. Selections have not been made but there are a number of seedlings that fruit heavily

and produce high quality fruits. The sour sop, *A. muricata* L., is next in popularity but it is more cold sensitive and seedlings are generally shy bearers. Heavy bearing clones which can be propagated by veneer grafting have been selected. The fruit is used mainly in ices, drinks, and ice cream. Two other species, the mountain soursop, *A. montana* Macfad., and pond apple, *A. glabra* L., produce fruit inferior in quality to the sour sop but can be used in the same manner. The latter is a native of South Florida and not cultivated, but the fruits are gathered from wild trees. The custard apple, *A. reticulata* L., produces fruit of fair quality but is seldom planted. The ilama, *A. diversifolia* Saff., is as hardy as the sugar apple and produces fruit of good quality with pink or white flesh. The ilama is a shy bearer and the seeds germinate with great difficulty. Propagation is by veneer grafting on rootstock of the sugar apple. The cherimoya, *A. cherimola* Mill., which has been grown in California with some success and where a number of varieties have been named, does very poorly in Florida. Many of the California varieties have been tested in Florida; they have made very poor growth and bear few fruit. A hybrid between the cherimoya and the sugar apple has been named "atemoya" and has done quite well in Florida. Two selections, the Page and Bradley, have been made and propagated by grafting. The fruit is quite agreeable and custard-like and eaten either as a fresh fruit or made into a drink or ice cream. (11, 58, 69)

Antidesma bunius Spreng, bignay, is well adapted to South Florida, but is not too well known. The plants are male and female with the latter producing fruits in currant-like clusters. The fruits make an excellent jelly as well as a fresh fruit juice. Considerable variation among seedlings occurs in the season of fruit maturity, even ripening, quality, etc. The Sub-Tropical Experiment Station has selected four heavy fruiting clones for field testing. They all produce fruit that ripens uniformly. Propagation of these selections is by air layers and grafting. (11, 30)

Antidesma dallachyanum Baill., Herbert River cherry, is similar to the bignay but the fruits are much larger, sometimes to ½ inch in diameter. They are also used to make a fresh fruit juice and an excellent jelly. One clone is on test at the Sub-Tropical Experiment Station and propagation is by air layers or grafting on *A. bunius* or *A. dallachyanum* seedlings. (11, 65)

Artocarpus altilis Fosb., breadfruit, is one of the most cold sensitive plants thus far grown in Florida and for this reason it is a rare tree and seldom seen. It is grown successfully only on the Florida Keys, especially in Key West, or in protected areas along Biscayne Bay where the temperature rarely falls below 40 degrees F. It makes a handsome tree and is well worth growing for its foliage. The fruit is baked, boiled, or roasted and can be used as a substitute for potatoes.

Artocarpus hypargyrea Hance, kwai muk, has recently fruited in Florida. The slender tree produces heavy crops of small, miniature jakfruits. The flesh is orange-red in color and the flavor is pleasant, mild, and subacid. No selections have been made. (11)

Artocarpus integrifolia L. f., jakfruit, is much hardier than the breadfruit and there are several large fruiting specimens in South Florida. These trees are all seedlings and the fruit produced is inferior, hardly being edible. No attempt has been made to introduce the so-called "honeyjaks" of southeastern Asia. The tree is large, handsome, and evergreen and the unusual fruit when well developed will weigh as much as 40 pounds. (11)

Averrhoa bilimbi L., the bilimbi or pickle fruit, is occasionally found in

Florida gardens where it is grown as an oddity. The fruit, to 4 inches long, is cylindrical and pickle-shaped and borne on the trunk and main branches. The fruit has a thin skin and firm flesh which is juicy but very acid and is used principally for relishes, pickles, syrup, etc. (11)

Averrhoa carambola L., carambola, is an attractive dooryard tree with a bright orange-yellow colored fruit which is star shaped in cross section. The fruit has been shipped to northern markets and has been favorably received but it is not grown commercially. One selection, a sweet variety, has been made. The tree bears 2 to 3 or more crops a year. The fruit is eaten fresh or used in salads, jellies, preserves, or as a fresh fruit juice. (11)

Blighia sapida Koenig, akee or vegetable brain, is grown in Florida more for its decorative effects than as an edible fruit. The bright red or yellow-red fruits usually produced in abundance are quite attractive. At certain stages before the fruit opens, it is poisonous and the black seeds are poisonous both in the opened and unopened fruit. When the fruit is mature, it splits open longitudinally into three parts exposing the black seeds and large white, contorted edible arils. They can be eaten fresh but are best when fried in butter and they can also be prepared in other ways. Only seedling trees are available, as no selections have been made. (11, 25, 43, 53)

Butia capitata Becc., jelly palm, is very hardy and can be grown throughout

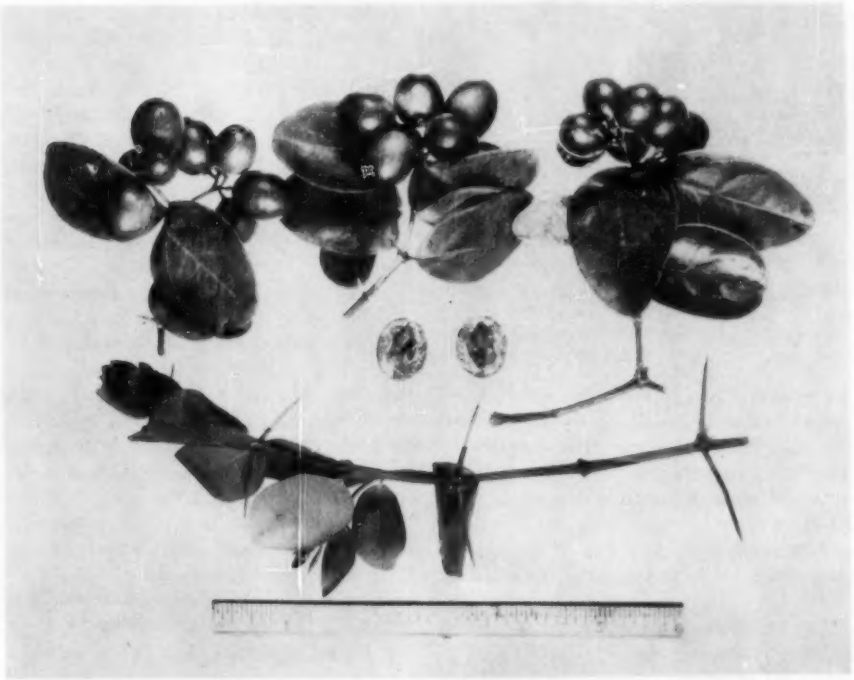

FIG. 4. *Carissa carandas*, karanda. The purple-black fruit makes a very good beverage.

FIG. 5. *Dovyalis*. Bottom right, yellow fruit of *D. abyssinica;* top right, purple-black fruit of *D. hebecarpa;* left and center right, foliage and orange-brown colored fruit of the hybrid.

Florida and in many of the other southern states as far north as Virginia. But, like the loquat, it rarely fruits outside of Florida. The fruit is produced in large clusters, each fruit to one inch across, bright yellow in color, with a thick flesh surrounding a large seed. The fruit is not eaten fresh but is used to make a jelly.

Calocarpum sapote Merr., mamey sapote, is rather rare in Florida. The trees are sensitive to cold and seedling trees usually take 10 or more years to flower and bear fruit. The fruit produced on the few trees in South Florida finds a ready market in such cities as Tampa. No selections have been made but there are improved forms in Cuba and an effort is being made to introduce some of these and to propagate them by grafting. The green sapote, *Calocarpum viride* Pittier, has not been grown to the fruiting stage in Florida although seedling trees are on trial.

Carica papaya L., papaya, has been grown in Florida for many years and at various times has been a commercial crop. Its culture is quite exacting, requiring frequent fertilizing and irrigation. Cold spells, winds, virus diseases, insects, fungus diseases, and nematodes have often made the commercial growing of papaya a rather hazardous undertaking. Propagation is by seed and it has been difficult to obtain and maintain pure lines. In Hawaii, the Solo is perhaps the closest to a pure line. This variety is not preferred in Florida as the plants grow quite tall and do not flower until 12–18 months old and the fruit is rather small. The types that have been named in Florida include the Betty, a dioecious form desirable only for home planting; the Blue stem, so named for the purple petioles, a hermaphroditic type that is well adapted for commercial production in Florida; and the Blue solo, a cross between the Blue stem and Solo. The Hortus Gold from Africa was a satisfactory variety for a while but the strain has run out. Papaya is well liked by many individuals but the vitamin and mineral content of the fruit as well as the medicinal values attributed to it are highly over rated. It is eaten principally as a fresh fruit and used in fruit salads. It is also prepared as a fresh fruit juice and a meat tenderizer, both products appearing on the market. (38, 82)

Carissa carandas L., karanda, is a thorny vine-like shrub. The fruit is oval or globular, to one inch long, and purplish-black in color. Some seedlings produce fruit that is quite tart, others are sweet. The fruit can be used to make a refreshing juice or carbonated drink and also for jelly. Some selections have been made for large fruit, good quality and heavy bearing. (11, 77)

Carissa grandiflora A. DC., natal or carissa plum, is a popular shrub in Florida for foundation planting and as a hedge barrier. It is well adapted for the

latter as it possesses very strong sharp thorns. The fruits are larger and redder in color than the karanda and of a sweeter taste. The fruit is eaten fresh or used in salads, jelly, sauces, pies, etc. Two varieties have been named and propagated, the Horne and Gifford. (11)

Casimiroa edulis Llave & Lex., and *C. tetrameria* Millsp., white sapote and woolly-leaved white sapote, respectively, are trees that produce large, yellowish, custard-like sweet fruit that is liked by many. The fruit is eaten principally as a dessert fruit. There are considerable variations in disease and insect susceptibility, fruit flavor, seediness, thickness of skin, and bitterness. In the improved clones the bitterness so characteristic of the white sapote has almost been eliminated. The Florida varieties include Dade, Blumenthal, Lenz, Page and Golden. The California varieties are Pike, Suebelle, Wilson, and Whatley. The white sapote is more cold resistant than many other subtropical fruits. It has never gained much popularity in Florida. (11, 52, 70)

Ceratonia siliqua L., Carob or St. John's bread, is not as popular in Florida as it is in California where it is valued as a desirable shade tree. The few trees in Florida are of seedling origin, and no attempt has been made to introduce the Californian varieties. The pods are very high in protein and sugar and are valued as an excellent feed for cattle and hogs. The pods can be made into flour which is highly prized as a health food. Syrup,

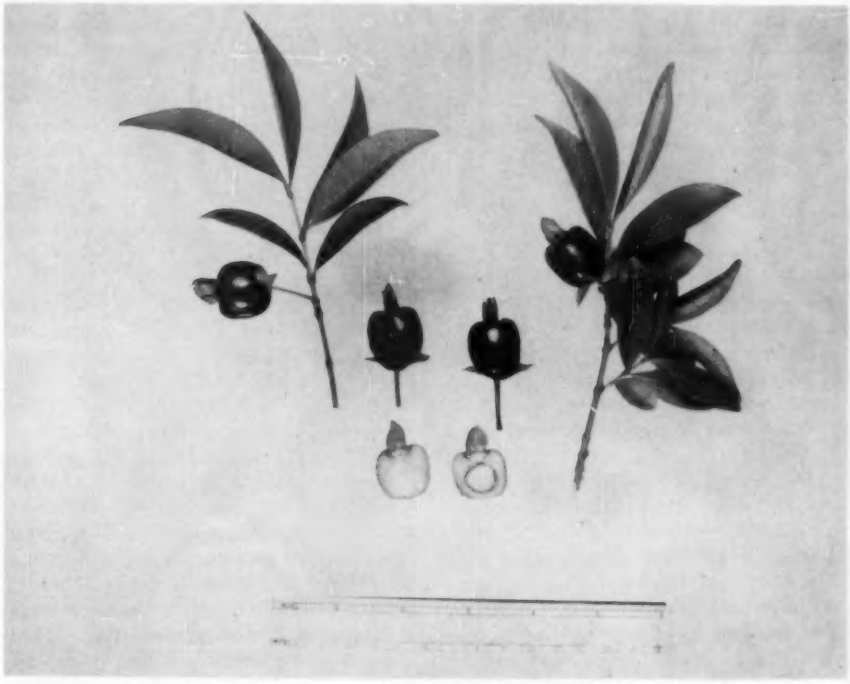

FIG. 6. *Eugenia aggregata*, Cherry-of-the-Rio Grande. The fruits are purple-black in color when mature and are eaten fresh. Below each fruit are two large heart-shaped bracts.

breakfast food and other items are made from the pods and seeds. A gum is extracted from the seed which can be used for many purposes in industry and in various foods. (28)

Chrysobalanus icaco L., cocoplum, a native plant, makes a handsome evergreen shrub useful in landscaping. The fruits are smooth and possess a thin skin, a white cottony pulp, and a large seed. There are two types depending on the color of the fruit—a dark purple form and a pale yellow or nearly white form. The fruit is not too desirable to eat out of hand, but it can be cooked with sugar to make a preserve and it can be used to make a jelly. (10)

Chrysophyllum cainito L., star apple, is valued both for its ornamental green and coppery colored leaves as well for its edible fruit. The latter when cut in cross section shows an interior shaped like a star as a result of the arrangement of the brown seeds and carpel segments. Considerable variation exists in seedlings —some are purple and some are green, the shape oval or globose, the size varying from one to 4 inches or more in length. Only a few selections have been made and these are propagated by grafting. (11, 51)

Clausena lansium Skeels, wampi, is little known in Florida. The few trees that have been grown produce a resinous fruit one inch in diameter that is pale yellow to yellowish green and can be eaten fresh or can be used in making pies, jellies, and drinks. No selections have been made as most of the seedlings produce an inferior fruit. (11)

Coccoloba uvifera L., sea grape, is a native to South Florida and is a popular ornamental shade tree with unusual large, round, thick leaves. The fruits are produced in hanging clusters and ¾ inch long, white to dark purple in color and with a large seed inside. The fruit is used to make a jelly which is very popular. There are considerable variations in size of fruit and in yields in seedling trees and a few selections have been made.

Cocos nucifera L., coconut, is the most popular palm throughout South Florida and is widely planted in yards and in parks. The fruit is eaten fresh or grated and used in making candies, pies, cakes, etc. Several attempts have been made in the past to grow the coconut commercially in South Florida, but these efforts have not been too successful. Very little selection has been made but the tendency is to select seeds from dwarf and precocious trees in order to obtain fruit early before the trees have grown so tall. The so-called Malay dwarfs, green, red, yellow, ivory, and golden, have been introduced and the golden form in particular has become popular.

Cyphomandra betaceae Sendt., tree tomato, has been grown successfully in South Florida but it is a short-lived plant and it has not gained much popularity in this State. (41)

Diospyros discolor Willd., mabolo or velvet apple, is an unusual fruit, globose in shape, and covered with reddish-brown hairs. The flesh is rather dry but sweet and aromatic. It is not relished by many because of its peculiar odor and is grown mainly for the decorative effect of the reddish-colored fruits. A seedless form is propagated by veneer grafting. (11)

Diospyros ebenaster Retz., black sapote, is a handsome evergreen tree which bears large fruit that is green when immature but turns to dark chocolate brown to nearly black when ripe. The fruit is eaten fresh and in many seedlings the fruit is quite insipid, but the better ones are sweeter tasting. The flavor may be improved by adding lime juice or wine to the mashed fruit. One clone with sweet fruit and heavy yields is on test at the Experiment Station. (11)

Diospyros kaki L., Japanese or oriental persimmon, is grown throughout

Florida and commercial plantings are sometimes made. The fruits sell readily on the market. The Tanenashi and Tamopan are popular varieties in Florida and 13 others have been described. (26)

Diospyros virginiana L. var. *mosieri* (Small) Sarg., South Florida persimmon, grows mainly in and around low hammocks bordering the Everglades in South Florida. It is similar to the northern persimmon but the plant is smaller, often a shrub, with round fruit with thicker skin and plump seeds. The fruit is orange-yellow in color and matures generally in September. The fruit is gathered from the wild trees and eaten fresh, made into preserves, jams, etc.

Dovyalis abyssinica Warb., African dovyalis, is a thorny shrub with fruits one inch in diameter, yellow orange in color, and with a flavor suggesting fresh apricots. The fruit quality is the best of the Dovyalis species. Unfortunately the plants are more difficult to grow than the other species and the hybrid, discussed below, is more desirable for this reason. (65)

Dovyalis caffra Warb., Kei apple, is a slow growing thorny bush. The fruit is very acid and is used mainly for sauces, preserves, and jellies. (11, 68)

Dovyalis hebecarpa Warb., Ceylon gooseberry, is a vigorous growing and very prolific, thorny, dioecious shrub. The fruit is purplish in color and is usually too acid to eat out of hand but is desirable for jellies, preserves, and fruit juice. (11)

Dovyalis abyssinica × *D. hebecarpa*, a natural hybrid, was recently distributed by the United States Department of Agriculture, as seedlings of PI 112086, *D. abyssinica*. The first generation seedlings of this cross have shown consider-

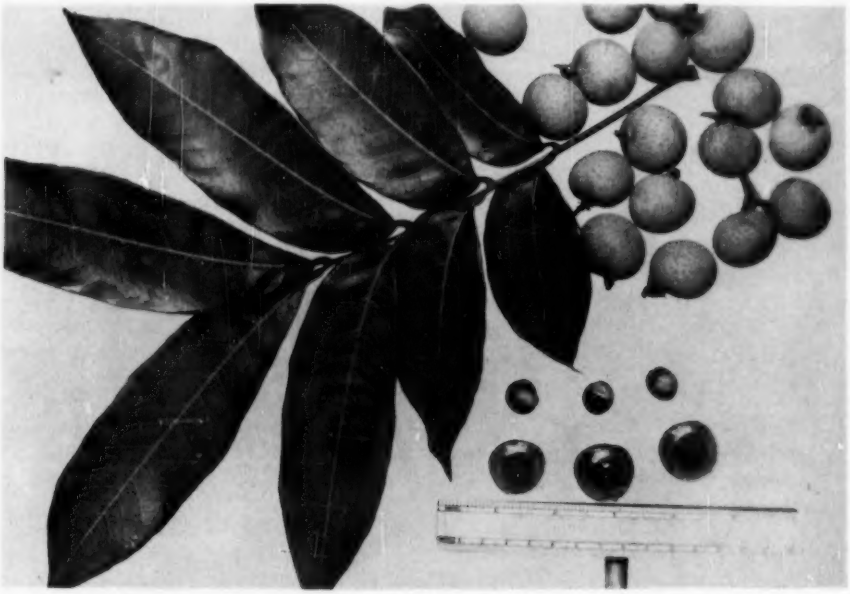

FIG. 7. *Euphoria longana*, longan, related to the lychee; the fruit is not as desirable as a fresh lychee but the plants are easier to grow.

able vigor, producing heavy yields of large-size fruit, and the plants either produce perfect flowers or male and female flowers on the same plant. The fruit is intermediate in color between the two parents, being a yellowish brown, and it is less acid than the Ceylon gooseberry. Several selections have been made and are propagated by air layering or grafting on seedlings of *D. hebecarpa*. The fruit can be eaten fresh or like the other Dovyalis species, made into a juice or jelly. (65)

Elaeagnus philippensis Perr., lingaro, is an ornamental scandant shrub with attractive foliage, very fragrant flowers, and pale red fruit which may be eaten out of hand or used to make a jelly. (11)

Eriobotrya japonica Lindl., loquat, is one of the favorite dooryard fruit plants in Florida. It can be grown throughout the state but it seldom flowers and fruits in the northern section. The foliage and flowers make it an attractive ornamental tree and the yellow-orange fruit produced in abundance during the winter and spring months are mostly eaten as a dessert fruit. They are also excellent when cooked with sugar to make a preserve or sauce or made into a pie. Since there is variation when grown from seed and since there are improved forms on hand, only grafted plants of named varieties are offered by nurseries. The varieties that originated in California are the Advance, Champagne, Early red, Premier, and Thales (Gold nugget). The Tanaka is from Japan and the Olivier from Algiers. Florida varieties include the Pineapple, Oliver (Olivier × Tanaka), and SES No. 4. The Sub-Tropical Experiment Station has a number of new seedlings on test and 15 of these seem promising. (11, 29, 39, 42)

Eugenia aggregata Kiaersk, Cherry of the Rio Grande, was introduced from Brazil to California and Florida in 1938 as *Myrciaria edulis*. However, this plant does not belong to the genus Myrciaria and it has recently been identified as *E. aggregata*. It is a hardy evergreen shrub producing white flowers, each of which are subtended by persistent heart-shaped bracts; the fruit is dark purple-red in color and is valued mainly for eating fresh.

Eugenia dombeyi Skells, grumichama, is also an attractive Eugenia shrub or small tree with evergreen foliage and purplish-black fruit that is eaten fresh. (11)

Eugenia luschnathiana Klotzch, pitomba, is another Brazilian myrtaceous shrub or small tree that makes an attractive ornamental plant. Its fruit is orange-yellow in color, larger and more flavorable than the two species listed above. The fruit is eaten fresh. (11)

Eugenia malaccensis Stokes, Malay apple, is represented by only one fruiting tree in Florida, but there are several other plants in the State that have grown successfully, but they are not mature enough to flower and fruit.

Eugenia uniflora L., Surinam cherry or pitanga, is a popular plant throughout most of Florida, being grown mostly as a hedge plant or used for foundation planting. The fruit is sub-globose in shape and red to nearly black in color. The flavor is resinous in most clones, but in the better types, sweet and only slightly resinous and more desirable for eating out of hand. The fruits can also be used in salads, jellies, sherbets, etc. The better clones are propagated by side grafting on seedlings, as cuttings and air layers have not been successful. (11)

Eugenia paniculata Banks, Australia brush cherry, is grown more for its ornamental value than for its fruits. The latter are purple in color and rather dry and insipid in taste, but they can be used for making jelly.

Euphoria longana Lam., longan, is not as well known nor as widely planted as the closely related lychee. The fruit, which is eaten fresh, is liked by many but it is usually considered as inferior to

the lychee. The Sub-Tropical Experiment Station has some selected clones on test. (11)

Feijoa sellowiana Berg., feijoa or pineapple guava, is a hardy shrub grown throughout Florida and other southern states as well. It is valued more for its ornamental foliage and flowers than for its fruit. The fruit is eaten fresh or used to make a jelly. Several of the California varieties—Andre, Coolidge, Choice, and Superba—have been propagated by veneer grafting, but most plants offered by nurseries are seedlings. (11, 71)

Flacourtia. There are four species of Flacourtia grown in South Florida. They are thorny shrubs that can be planted as a hedge or as specimen plants. The fruit is eaten fresh or used to make a jelly or pie. *F. indica* Merr. (*F. ramontchi* L'Her.), ramontchi or Governor's plum, is best known and is a common hedge plant. It is typically thorny, but at the Sub-Tropical Experiment Station a thornless clone which produces large crops of good quality, is under observation. *F. rukam* Zoll. and Mor., rukam, and *F. cataphracta* Roxb. (*F. jangomas* Gmel.), the paniala, are similar to *F. indica* but they produce fruits in clusters instead of singly. No selections of the paniala have been made, but the Sub-

FIG. 8. *Litchi chinensis*, lychee. A fruiting tree 8 years in the field makes a handsome plant.

Tropical Experiment Station has one thornless clone of the rukam on test. The fourth species, *F. inermis* Roxb., Lovi-lovi, is relatively rare in Florida; its fruits are bright red in color and are generally quite acid. (11)

Garcinia livingstonei Anders., imbe, is an odd-shaped, dioecious plant with attractive orange-colored fruit. The latter is very thin-fleshed with a large seed. The flavor of the fruit from seedlings varies considerably but no selections have been made for propagation. (11)

Hylocereus undatus Britt. and Rose, night blooming cereus or strawberry pear, is a popular plant grown for its unusual large nocturnal flowers. The fruit is a large red berry with white juicy edible pulp of indifferent quality and flavor. *H. guatemalensis* Britt. and Rose is similar but differs in having a red pulp. (11)

Litchi chinensis Sonn., lychee, a handsome dooryard tree, has in recent years become a small commercial crop with promise of further development in the central part of the state where the soil is sandy and acid. Because of the interest displayed in the commercial possibilities of this fruit, the Lychee Association of Florida was founded in 1952 to promote the fruit. In 1956 it was estimated that there were about 400 acres consisting of 15,000 trees, half of which are non-bearing. The Brewster is the only variety grown at the present time in Florida. It was sent to Florida in 1903 and again in 1906 by Rev. W. N. Brewster and later named for him. Subsequent investigations have identified this variety as the Chen-tze. Many of the other named Chinese varieties have been tried in Florida but none of them has been as successful as the Brewster. The Groff, a recently named variety in Hawaii, is on trial. A number of seedlings in Florida are under observation and many named Chinese varieties are under trial. Recently a seedling growing at the U. S. Plant Introduction in Miami has been named the Bengal. It is more adapted to alkaline rock soil than the Brewster. The lychee is marketed principally as a fresh fruit and those who taste it find it quite agreeable and far superior to the dried lychee nuts. Lychees are not as yet dried in Florida as they are in China. Canning of the fruit has been successful but this product has not been exploited. The fruit can also be frozen. (27, 31, 35, 50, 73, 75)

Macadamia ternifolia Muell., macadamia nut, is a commercial crop in Hawaii and it has aroused the interest of many individuals in both Florida and California as a potential crop in these states. A number of seedlings are under test at the Sub-Tropical Experiment Station and four of these are of special interest, but only two selections have been propagated and only one of these is really of any value. Yields and percentages of kernel to whole nut from these and other seedling trees have, on the whole, been inferior to the named Hawaiian selections. Some of the latter as grafted plants are on test in Florida. The macadamia nut is one of the most delicious nuts and is very rich in food value. It is well received by those who have tasted it either fresh or roasted. The difficulty of cracking the extremely hard shell has been overcome in Hawaii where special nut cracking machines have been devised. The macadamia is well adapted to Florida, particularly in acid soils. The main problem in Florida is to find high yielding clones from among the seedlings already growing in the State and from those recently planted. (34, 37)

Malpighia glabra L. (or *M. punicifolia* L.), West Indian cherry, Barbados cherry, or "Acerola", has been in Florida for many years as a dooryard plant. In recent years it has attracted considerable attention after the discovery of the high vitamin C content of

the fruit. The latter is far greater than that of citrus and guava; from 1,000 to over 4,000 mg. ascorbic acid per 100 grams of juice have been reported. Considerable work on culture and clonal selection has been done in Puerto Rico where one selection has been named "B-17". At the Sub-Tropical Experiment Station several clones are on test. One in particular is high yielding, possesses sweet tasting fruits, is of large size and good quality, with a high vitamin C content. It has been named "Florida Sweet". The fruit of the West Indian cherry is mainly eaten fresh, but it can be made into a fruit juice, ice, jelly, etc. Perhaps its best use is as a frozen concentrate, similar to orange juice concentrate, but this product has not been exploited as yet. One commercial use has been to fortify the vitamin C content of baby foods. (47, 49, 55)

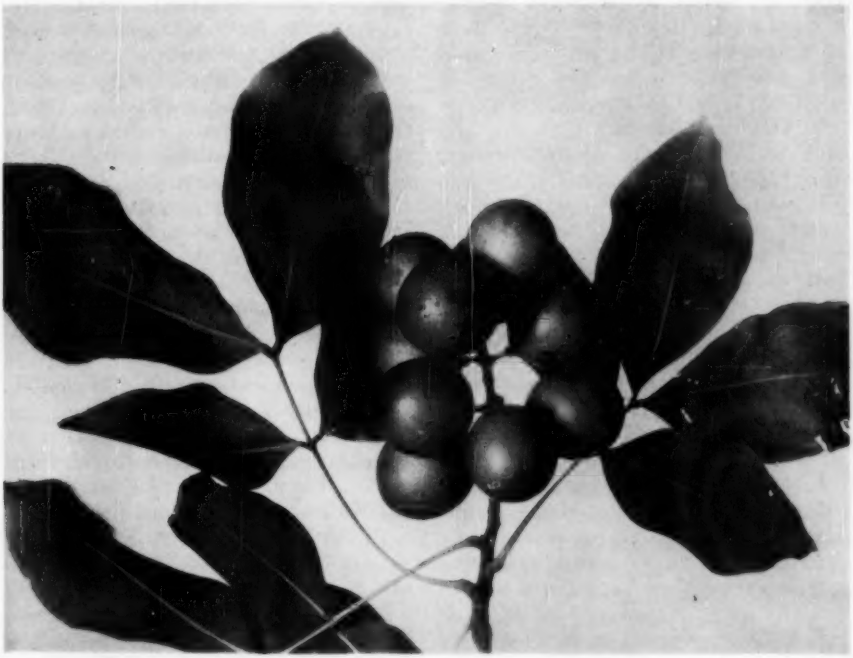

FIG. 9. *Melicocca bijuga*, Spanish lime. The fruits are light green in color and superficially resemble a true lime, but it is related to the lychee and longan.

Mammea americana L., mamey apple, is rare in Florida and only a few fruiting trees can be found. It is a handsome evergreen tree with large round fruit, the skin of which is rough and russetted. The flesh is firm, yellowish or reddish and varies in flavor from sweet to subacid. It is eaten out of hand or sliced and served with sugar and cream. No selections have been made.

Mangifera indica L., mango, can be grown commercially in the United States only in peninsular Florida. It is well known and a popular fruit to many Floridians and has been planted for many years as a dooryard fruit tree and in commercial groves. The fruit is eaten

fresh, but it can be canned, frozen, and has many other uses. The mangos grown in Florida are conveniently classified into four groups as follows:

1. Varieties introduced from India, which include Mulgoba, Amini, Paheri, Sandersha, Rajpuri, and other varieties. The plants or grafting material were originally brought to this country many years ago by the United States Department of Agriculture. With the exception of the Amini, they have never performed well in commercial plantings and today are found mainly in botanical collections.

2. Varieties or types introduced from the West Indies and South America. This group includes the Turpentine and Number 11 as well as such forms as apple, peach, apricot, pineapple. They were brought into Florida from the West Indies nearly a century ago and a large number of trees are scattered throughout Florida. They fruit abundantly and are used mainly as rootstocks.

3. Varieties or types introduced from the Philippines and French Indo-China. These are the Philippine and Saigon mangos and some, like the Carabao and Pico, are well known in the Philippines. Others, like the Manila of Mexico, Cambodiana, Cecil and Saigon, were introduced to Florida as seeds, but being polyembryonic they come fairly true to type.

4. Varieties originating in Florida as first generation seedlings of Indian varieties (such as Brooks, Haden, Keitt) or second generation seedlings (such as Fascell, Irwin, Kent, Lippens, Smith, Zill). This group also includes some Saigon types that originated in Florida and are propagated vegetatively—such as the Earlygold, Florigon, Glenn, and the Edward, the latter thought to be a cross between the Haden and Carabao. Thirty-nine Florida mango varieties have been named and described, of these only 24 are propagated by nurseries, but only about 12 are planted commercially. For commercial purposes, Irwin, Kent, Keitt, Palmer, Sensation, and Zill are leading varieties at the present time. Most of these are also desirable for home planting, but Edward, Carrie, Saigon, Florigon and Glenn are considered more desirable for this purpose.

Seedling selection is the method used for finding new varieties. The Florida Mango Forum, founded in 1938, is active in searching for new varieties. Each year 40 to 50 new mangos are sampled and out of these one or two may be worth further observation. Experiment Stations and many of the leading nurseries plant out many seedlings with the hope of finding a better mango. The varieties now available extend the mango season from late May to September and even into October. In 1954 it was estimated that there were about 4,000 acres of mangos in commercial production, the majority being planted in three counties on the lower southeast coast from Palm Beach to Homestead. In the past six years mango production in Florida has continued to increase. Since 1952 fruit shipped out of the State to northern markets has increased as follows: 1952—417,000 lbs.; 1953—859,600 lbs.; 1954—1,031,200 lbs.; 1955—1,196,500 lbs.; 1956—1,422,400 lbs.; 1957—1,973,600 lbs. (32, 54, 57, 66, 76)

Melicocca bijuga L., Spanish lime or mamoncillo, is a rather rare tree on the mainland but is popular in Key West. Most of the seedlings produce fruit that is quite acid and little selection has been made. Recently, however, a large, sweet type was found in Key West and it has been propagated by air layering and inarching. (11)

Monstera deliciosa Liebm., ceriman, is grown mainly for its foliage and indeed it is an attractive tropical plant. It is often seen as a house plant in homes and conservatories in the north and in Florida it is grown out of doors. The large calla-lily-like flowers are produced

from August to October and the fruit, which resembles a large green ear of corn, matures 12 to 14 months later. Immature fruit contains calcium oxalate crystals but these are absent at maturity. The fruit has a pineapple-banana-like odor and taste and can be eaten fresh or used in salads. (11)

Muntingia calabura L., capulin or Panama berry, is an attractive quick-growing, small shade tree producing small, white flowers followed by small red or yellow berries that are sweet, juicy, and eaten out of hand. They can also be used to make tarts and jam. (11)

Musa spp. Like the ceriman (*Monstera deliciosa*), bananas furnish a tropical effect and these plants are often included in landscaping home grounds for this reason. The variety most planted in Florida is the apple. It is fairly hardy and is quite prolific; the fruits are short and plump and of good flavor. The cavendish is a dwarf type and is quite hardy and more tolerant of wind because of its dwarfness. Occasionally it is planted commercially on a small scale and the fruits are sold in local markets. The lady finger is a very rare type and is often confused with the apple. Gros Michel, the chief commercial variety in the American tropics, is not grown to any extent in Florida but it can be found in collections. Cooking bananas or plantains such as the Orinoco (also called horse or hog banana) are occasionally planted. (11, 60)

Myrciaria cauliflora Berg., jaboticaba, is a Brazilian fruit resembling a large concord grape. The fruits are produced all along the trunk and on larger branches. The fruits are eaten fresh and can be frozen. They also make a good jelly, juice and wine. The plant will, in its native country, grow to be a large spreading tree, but in Florida the jaboticaba is a low growing shrub or small tree. The seeds are polyembryonic and therefore most seedlings come true to type. Paulista, Sabra, Blanca, Guamixama are Brazilian varieties known to be planted in Florida. (11, 30, 80)

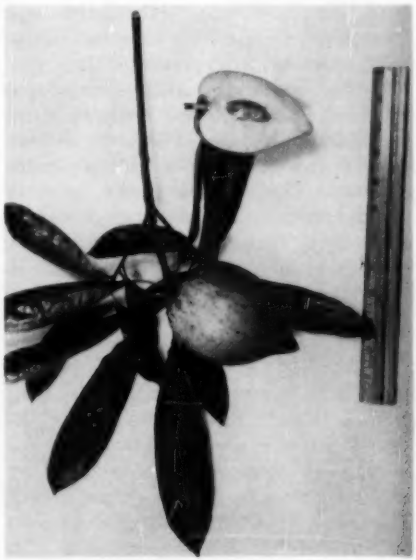

FIG. 10. *Pouteria campechiana*, Canistel or egg fruit. The fruit is yellow in color and the flesh is dry and orange colored.

Passiflora edulis Sims and *P. edulis* variety *flavicarpa* Deg., purple and yellow passion fruits, are grown commercially in Australia, Hawaii, and other countries and are sometimes planted in Florida as ornamental flowering and fruiting vines. The fruits are valued for the juice which is sometimes used fresh but more often prepared in ices, ice cream, sherbets, etc. (11)

Passiflora quadrangularis L., giant granadilla, is not widely planted in Florida. It is an ornamental vine with large attractive flowers and fruits to 6 inches or more in length with a thick shell and a cavity with seeds embedded in juicy subacid pulp. The fruits may be eaten fresh or made into a juice. It is the source of Grenadine.

Pereskia aculeata Mill., Barbados

gooseberry, is a spiny, leafy cactus vine. The small yellow fruit is eaten out of hand or made into a preserve.

Persea americana Mill., avocado, is the leading commercial fruit of South Florida with about 10,000 acres in commercial groves, 90 percent being located in Dade County where the industry amounts to a million dollars. A leading commercial variety must possess, among other things, a green skin, and small seed, and the tree should be relatively hardy, bear heavy crops and with little tendency to alternate bearing. New varieties are being constantly tested and some which were favorites years ago, such as the Collinson, Winslowson, and Trapp, are little planted today. The leading commercial varieties at the present time are Lula, Booth 7 and Booth 8. The Mexican race, which is the hardiest but with the smallest fruit, is not recommended for Florida but is the leading type in Texas. The Guatemalan race, which is less hardy than the Mexican but with larger fruit, is planted in both Florida and California. The West Indian race is most tender and is recommended only for Florida. Hybrids of the West Indian and Guatemalan have proved very successful in Florida, while one, the Lula, is said to be a hybrid of Guatemalan × Mexican but this is questionable. The varieties in Florida bear fruit from late June to the following April and it is possible, then, to have fruit available practically the year around. The West Indian varieties generally bear fruit early and include the Fuchs, Trapp, Pollock and Waldin. The Guatemalan types fruit late in the season and include Itzamna, Nabal, Linda, and Taylor. The West Indian × Guatemalan types mature fruit in mid-season and include Marguerite, Booth 7, Booth 8, Hall, and Hickson. The avocado has become a popular fruit throughout the country. It is eaten fresh, mainly in salads, but it can be prepared in many other ways. Recently a frozen product has appeared on the market. (40, 81)

Phyllanthus acidus Skeels, Otaheite gooseberry, is a small tree with nearly globular, 6-lobed, yellow-green fruit that is quite acid and used mainly for pies and preserves. (11)

Phyllanthus emblica L., the emblic or myrobalan, is similar but with finer foliage, larger fruit which is round and with a smooth green skin. The fruit is quite acid and it contains a high amount of ascorbic acid. (56)

Pouteria campechiana Baehni, canistel or egg fruit, is quite variable in habit, leaf shape, and size, shape and texture of the fruit. The fruit varies from 2 to 6 inches in length and from subglobose to ovoid in shape. It is orange colored when mature, both inside and outside. The fruit is eaten raw, cooked or can be used in making an eggnog. A number of seedlings at the Sub-Tropical Experiment Station have been selected for large fruit size and heavy bearing; they have been veneer grafted on seedling rootstock and are being tested in the field. (11)

Prunus persica Sieb. & Zucc., Red Ceylon peach, introduced from Ceylon in the early 1880's, has been grown in South and Central Florida for many years. The fruit is small, although with good culture its size is increased, and the trees bear heavy crops every year. This peach has an extremely low chilling requirement for flower induction and for this reason it is considered a tropical variety. The fruit has to ripen on the tree and is, therefore, not a commercial variety and is recommended only for home planting. (72)

Psidium cattleianum Sab., cattley or strawberry guava, is an attractive dark green, evergreen, thick-leaved shrub with reddish brown bark. It is a hardy ornamental shrub that can be grown throughout most of Florida. It is called strawberry guava because in one variety the fruit is red in color. The fruit is small

with a sweet flavor. The yellow-fruited form is variety *lucidum* Hort., and is called the yellow cattley guava. The fruit is eaten fresh, made into a jelly, or used as a desert fruit when served with sugar and cream. (11, 67)

Psidium guajava L., common guava, is less exacting in its culture than the other tropical fruits and it produces fruit over long periods. It is often called the "apple of the tropics". It is quite common in Florida, having escaped from cultivation, and has at times been a small commercial crop. Most plants are of seedling origin and there is considerable variation in fruit quality, bearing, and especially in odor. The latter is probably the reason guava is so objectionable to many individuals. But in recent years selection has been made for mild flavor forms that are sweet and with little if any of the objectionable odor. Also, selection has been for large size, heavy crops, large thick flesh with few seeds, and small seed cavity. These are the dessert guavas and they are quite different from the so-called wild acid guavas which, because of their high pectin and acid content, are best for jelly making. The Supreme bears heavy crops of thick walled, subacid white fleshed fruits of good quality. The Red Indian and Ruby, both red fleshed, are sweet, large fruit of high quality. At the Sub-Tropical Experiment Station a number of seedlings representing hybrids of Supreme and Ruby are on test. Guava is usually an excellent source of ascorbic acid, some fruits ranging as high as 500 mg. per 100 grams edible matter. Uses

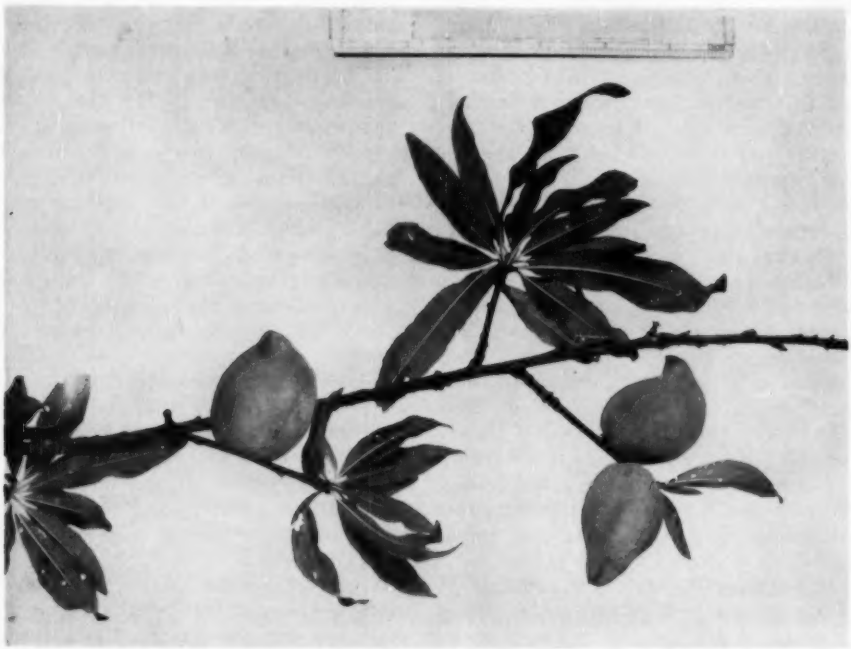

FIG. 11. *Prunus persica*, the Red Ceylon peach, a tropical variety from Ceylon, it flowers and fruits with less than 35 hours of temperature below 45 degrees.

of the fruit are many: the better types are eaten out of hand or as fresh sliced fruit served with sugar and cream or mixed with other fruits. The guava can be cooked to make sauces or preserves; it can be canned or frozen; it can also be made into a juice, jam, butter, marmalade, relish, catsup, chutney, punch, pie, shortcake, or ice cream. (61, 62, 64, 74, 79)

Rhodomyrtus tomentosa Wight., downy gooseberry, is grown only in the acid sands of South and Central Florida. It is an attractive hardy shrub with small, round fruits, greenish-purple in color and with a sweet flavor. The fruits are used in jams and pies. (11)

Rubus albescens Roxb., tropical or Mysore black raspberry, like the Red Ceylon peach, has a very low chilling requirement for flower induction. It flowers and fruits from December to June producing very heavy crops. The fruit is sweet and of mild flavor. It is grown as a dooryard fruit plant but a few small commercial plantings have been made, the fruit being sold mainly on roadside fruit stands. There seems to be very little variation in fruit quality when raised from seed and therefore no selections have been made and propagation is by seed. (45, 48)

Solanum quitoense Lam., naranjilla of Ecuador, has been grown successfully in Florida by grafting the root-knot sensitive naranjilla onto *Solanum macranthum*, a root-knot resistant species. The plants live for about three years and grow to about 10 feet in height. They have attractive large red-fuzzy leaves and large fruits which resemble small oranges. The fruit makes an agreeable refreshing juice which is green in color and rich in food value. It is highly esteemed in Ecuador. (44)

Spondias cytherea Sonn., ambarella or Otaheite apple, is grown to a limited extent in South Florida. It becomes a large spreading tree and produces large clusters of plum-like fruit 2–3 inches long; the fruit varies from sweet to acid in taste. It is the best of the *Spondias* species but the fruit has objectionable woody fibers extending out from the solitary stone into the pulp and make difficult its removal. The taste is comparable to a medium grade apple or mango. It is eaten fresh or it can be cooked to make a preserve, sauce, and jelly. Selection is for sweet tasting fruit which is large in size and with a small stone and short fibers. (11)

Spondias mombin L., yellow mombin, is a tall growing tree with fruits that resemble the ambarella except that they are much smaller, to one inch long, and oval in shape. They are yellow in color and possess a small amount of pulp surrounding a large stone. The fruits are eaten fresh or made into a jelly. (11)

Spondias purpurea L., red or purple mombin, is a spreading tree with fruit dark red or purple in color, 1 to 2 inches long, and with a large stone and an outer covering of reddish colored flesh. The fruit is eaten fresh or made into a jelly. There is a yellow fruiting form which matures in the fall instead of the summer months; it has been confused with *S. mombin*. (11)

Syzygium cumini Skeels, Jambolan plum, is a popular evergreen fast growing shade tree sometimes planted as a windbreak. The fruit is up to 1½ inches in diameter and purple in color. It is not desirable as a fresh fruit since it is very astringent. The fruit is used to make a jelly, juice or wine. There is considerable variation in seedling trees in fruit quality, size and bearing, but no clones have been selected for propagation. (11)

Syzygium jambos Alston, rose apple, is a large attractive tree often planted as a specimen shade tree. The flowers are large, white, and showy. The fruit is up to 2 inches in diameter, round, pale yel-

low, and with a large cavity filled with 1 to 3 large brown seeds. The fruit can be eaten fresh and used in salads, but its resemblance to sweet rose water is not liked by many. It is better when candied, preserved, especially in brandy, or made into a jelly. (11)

Tamarindus indica L., tamarind, is a slow growing but very desirable tree for South Florida and it is frequently used as a shade tree. The fruit is a pod to 7 in minerals, especially calcium and phosphorus, and is a good source of thiamine. One seedling has been selected for propagation because of its large fruits and heavy yields. (11)

Triphasia trifoliata P. Wils., lime berry, is a dwarf shrub producing a small, oval fruit that is dark red at maturity. The flavor is sweet, aromatic and slightly resinous. The fruit is eaten out of hand or made into a drink or jelly.

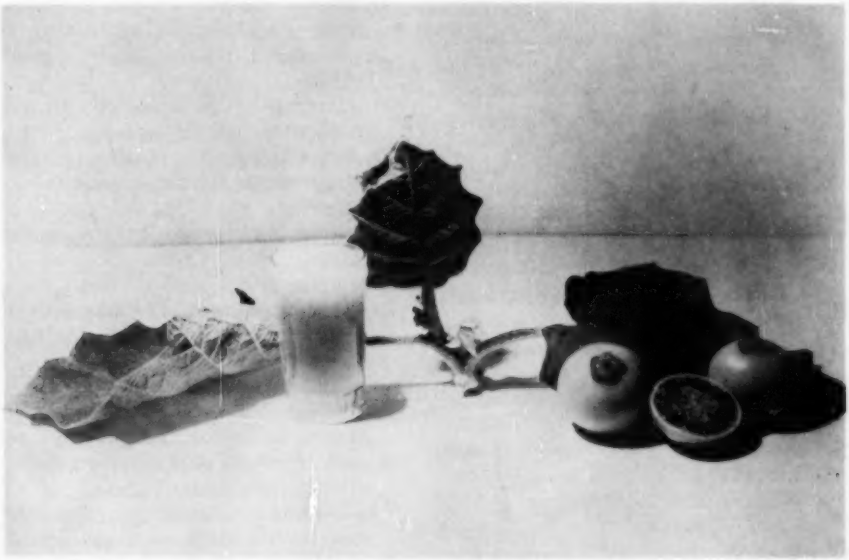

FIG. 12. *Solanum quitoense,* naranjilla, a popular fruit in Ecuador, is extremely sensitive to root-knot nematode and to grow it successfully in Florida it must be grafted on a root-knot resistant species of Solanum.

or more inches long, consisting of large flat seeds around which is a firm, glandular, sticky, brown pulp which is edible. It is date-like in consistency, high in sugar and tartaric acid, and tastes both sweet and sour. Seedlings vary considerably in size of fruit, sweetness, and yield. The fruit can be eaten fresh or used to make a tamarind ade; it is also used for flavoring preserves, chutney and meat sauces. The fruit is very high

Zizyphus mauritiana L., Indian or Malay jujube, is a vigorous growing spiny tree with leaves dark green above and white below. The fruit varies in shape from globular to oval and from greenish yellow to reddish brown in color. It is mildly subacid in flavor and can be eaten fresh, made into a jelly, preserve, sauce, or can be candied. The flavor is reminiscent of a wild crab apple. No selections have been made. (11)

Check List of Fruit Plants, Other Than Citrus, Grown in Peninsular Florida

Anacardiaceae

Anacardium occidentale L. Cashew. West Indies and Tropical America.

Mangifera indica L. Mango. Southeastern Asia.

Spondias cytherea Sonn. Ambarella or Otaheite apple. South Pacific.

S. mombin L. Yellow mombin. Tropical America.

S. purpurea L. Red or purple mombin. Tropical America.

Annonaceae

Annona cherimola Mill. Cherimoya. Peru and Ecuador.

A. diversifolia Saff. Ilama. Mexico and Central America.

A. glabra L. Pond apple. South Florida, West Indies, Tropical America.

A. montana Macfad. Mountain soursop. West Indies.

A. muricata L. Soursop, guanabana. Tropical America.

A. reticulata L. Custard apple. Tropical America.

A. squamosa L. Sugar apple. Tropical America.

A. cherimoya × *A. squamosa*. Atemoya (Florida).

Apocynaceae

Carissa carandas L. Karanda. India.

C. grandiflora A. DC. Carissa or Natal plum. South Africa.

Araceae

Monstera deliciosa Liebm. Monstera or ceriman. Mexico and Guatemala.

Bromeliaceae

Ananas comosus Merr. Pineapple. Tropical America.

Cactaceae

Hylocereus guatemalensis Britt. & Rose. Night blooming cereus. Guatemala.

H. undatus Britt. & Rose. Night blooming cereus or pitaya. Mexico.

Pereskia aculeata Mill. Barbados gooseberry. West Indies.

Caricaceae

Carica papaya L. Papaya. Tropical America.

Cassiaceae

Ceratonia siliqua L. Carob or St. John's bread. Mediterranean region.

Tamarindus indica L. Tamarind. Tropical Africa.

Ebenaceae

Diospyros discolor Willd. Velvet apple or mabolo. Philippines.

D. ebenaster Retz. Black sapote. Mexico.

D. kaki L. f. Japanese or oriental persimmon. China or Japan.

D. virginiana L. var. *Mosieri* (Small) Sarg. South Florida persimmon.

Elaeagnaceae

Elaeagnus philippensis Perr. Lingaro. Philippines.

Elaeocarpaceae

Muntingia calabura L. Capulin or Panama berry. West Indies and Tropical America.

Euphorbiaceae

Antidesma bunius Spreng. Bignay. Malayasia to West Australia.

A. dallachyanum Baill. Herbert River cherry. Australia.

Phyllanthus acidus Skells. Otaheite gooseberry. Madagascar and India.

P. emblica L. Emblic or myrobalan. Tropical Asia.

Flacourtiaceae

Dovyalis abyssinica Warb. African gooseberry. Ethiopia.

D. caffra Warb. Kei apple. South Africa.

D. hebecarpa Warb. Ceylon gooseberry or kitembilla. Ceylon.

D. abyssinica × *D. hebecarpa*. *Dovyalis* hybrid. (Florida).

Flacourtia cataphracta Roxb. Paniala. India and Malaya.

F. indica Merr. Governor's plum or ramontchi. Madagascar and Southern Asia.

F. inermis Roxb. Lovi-lovi. Malaya.
F. rukam Zoll & Mor. Rukam. Malayasia.

Guttiferae
Garcinia livingstonei Anders. Imbe. East Africa.
Mammea americana L. Mamey apple. West Indies, South America.

Lauraceae
Persea americana Mill. Avocado. Tropical America.

Malpighiaceae
Malpighia glabra L. Barbados cherry, West Indian cherry, acerola. Tropical America.

Moraceae
Artocarpus altilis Fosb. Breadfruit. Java and other islands.
A. hypargyrea Hance. Kwai Muk. South China.
A. integrifolius L. f. Jakfruit. India, Malaya.

Musaceae
Musa paradisiaca L. Plantain. India.
M. paradisiaca var. *sapientum* Kuntze. Banana. India.
M. nana Lour. Dwarf or Cavendish banana. South China.

Myrtaceae
Eugenia aggregata Kiaresk. Cherry-of-the-Rio Grande. Brazil.
E. dombeyi Skells. Grumichama. Brazil.
E. luschnathiana Klotzch. Pitomba. Brazil.
E. malaccensis Stokes. Malay apple. East Indies and Malaya.
E. paniculata Banks. Brush cherry. Australia.
E. uniflora L. Surinam cherry, pitanga. Brazil.
Feijoa sellowiana Berg. Feijoa, pineapple guava. South America.
Myrciaria cauliflora Berg. Jaboticaba. Brazil.
Psidium cattleianum Sab. Cattley or strawberry guava. Brazil.
P. guajava L. Guava. Mexico to northern South America.
Rhodomyrtus tomentosa Wight. Downy myrtle, hill gooseberry. India.
Syzygium cumini Skeels. Jambolan or Java plum. Southeast Asia.
S. jambos Alston. Rose apple. East Indies.

Oxalidaceae
Averrhoa bilimbi L. Bilimbi, pickle fruit. Malayan region.
A. carambola L. Carambola. Malayan region.

Palmaceae
Butia capitata Becc. Jelly palm. Brazil.
Cocos nucifera L. Coconut. South Pacific.

Passifloraceae
Passiflora edulis Sims. Passion fruit.
P. edulis var. *flavicarpa* Deg. Brazil.
P. quadrangularis L. Granadilla. Tropical America.

Polygonaceae
Coccoloba uvifera L. Sea grape. South Florida and Tropical America.

Proteaceae
Macadamia ternifolia Muell. Macadamia or Queensland nut. Australia.

Rhamnaceae
Zizyphus mauritiana Lam. Indian or Malaya jujube. India.

Rosaceae
Chrysobalanus icaco L. Cocoplum. South Florida and West Indies.
Eriobotrya japonica Lindl. Loquat. China.
Prunus persica Sieb. & Zucc. Red Ceylon peach. Ceylon.
Rubus albescens Roxb. Mysore black raspberry. India.

Rutaceae
Casimiroa edulis Llave & Lax. White sapote. Mexico and Central America.
C. tetrameria Millsp. Woolly-leafed white sapote. Mexico, Central America.
Clausena lansium Skeels. Wampi. South China.

Triphasia trifoliata P. Wils. Limeberry. Tropical Asia.

Sapindaceae

Blighia sapida Koenig. Akee. West Africa.

Euphoria longana Lam. Longan. South China.

Litchi chinensis Sonn. Lychee. South China.

Melicocca bijuga L. Spanish lime, mamoncillo. Tropical America.

Sapotaceae

Achras zapota L. Sapodilla. Mexico and Central America.

Calocarpum sapota Merr. Mamey sapote. Central America.

Chrysophyllum cainito L. Star apple. Tropical America.

Pouteria campechiana Baehni. Canistel or egg fruit. Central America.

Solanaceae

Cyphomandra betacea Sendt. Tree tomato.

Solanum quitoense Lam. Naranjilla. Ecuador.

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Utilization Abstracts

Synthetic Fiber from Lignin. A technique for converting the by-product of paper pulp and cellulose production, lignin, into a fiber has been described by Dr. Louis H. Bock and James K. Anderson of Rayonier, Incorporated. The new fiber has been shown in tests to have tensile strengths as high as 4.4 grams per dernier and a melting point of 419° F. It also has displayed good dyeing properties and low water absorption.

The synthetic fiber, a polyester, is based on vanillin, converted in the process into another substance known as protocatechuic acid. It has been reported that protocatechuic acid is also obtainable from the bark and needles of western hemlock. (*Anon., Chemurgic Digest 16(10): 10. 1957.*)

Ponga Ware. Vases, powder-bowls, and ash trays are made out of sections of the cleaned, bleached, and cured stem of the New Zealand tree-fern *Cyathea medullaris* from which the outer fibers and central pith have been removed, leaving a cylinder of hard tissue. The exterior surface of the stem is usually polished and varnished. The finished product, into which a glass or metal container for water may be fitted, sells for several dollars. The fibers of this fern are used in orchid culture, and the whole trunks for garden paths, drain-pipes, fences, fernhouses, and for holding banks. (R. Cooper, *Amer. Fern Journ. 47(3): 89–90. 1957.*)

JOHN W. THIERET

BOOK REVIEWS

Studier över Släktet Taraxacum Wigg. med särsklid Hänsyn till Gruppen Vulgaria DT i Skandinavien. ("Studies on the genus Taraxacum Wigg. with special reference to the group Vulgaria DT in Scandinavia.") Carl Gustaf von Hofsten. Stockholm: LTs Forlag, 1954. Pp. 432. (Illustrated). (c. $4.50).

At the hands of a modern botanist of Upsala the common dandelion has received one of the most exhaustive examinations ever accorded so ubiquitous a weed. In view of the current interest in weed biology it is profitable to review here the many factors which have led to this survival and world-wide dispersal. While the text is in Swedish all legends and footnotes to the 73 tables, to the 27 graphs and figures, and to the superb illustrations (176 in number!)—as well as the 32-page summary—are all in English. More than a thousand species have been described in the genus *Taraxacum* (Compositae); though Handel-Mazetti (1907) recognized only 57 species in the entire world. However the combined action of hybridization, polyploidy and apomixis has produced a very complex taxonomic situation. In field studies covering 15 years, principally around Ultuna, Sweden, involving more than 8,000 individuals, 79 apomicts were studied and graded for values of aggressiveness. Following detailed cytological studies, the successful production of new apomicts by X-ray treatment of acenias, and by the discovery of several new apomicts around Ultuna, it was concluded that mutations were the main reason for the formation of new *Taraxacum* apomicts. It was also concluded that the weedy *Vulgaria* group did not belong to the original flora, but that the anthropochore units of this group still may have existed in Scandinavia as early as 3,000 years ago.

The flowering biology varied within different apomicts. Newly discovered apomicts, such as *picinum* Hagl. produced an average of 20.8 calycles per plant per day for the total flowering period (26 days) in contrast to the poorest flowering *trilobatum* Palmgr. which had 4.7 calycles per plant for the flowering period (33 days). Differences among the apomicts also were noted in height of flowering stems, numbers of acenias per calycle, acenia weight and falling speeds. Studies of the accumulation of plants near the mother plant indicated the dispersal range seldom exceeded two to three m. along ditches and roadbanks; while long distance dissemination in fields seldom exceeded 30 m. However, the dissemination from the gigantic stands on cultivated areas was estimated to hardly exceed 200–500 m. It was also noted that mother plants may survive as long as 15 years.

Distribution studies of the dandelion seeds on the soil surface indicated the importance of the wind and rapidly moving vehicles whereby the pappus catches the air, and both its hygroscopic movements and the spinuli of the acenia are important for the piling of seeds in the ground cracks. The author observed the amount of seeds per unit area brought on the ground during each vegetation period at from 10,000 to 20,000 per sq. m.; while the greatest number of plants ever observed was up to 500 per sq. m. in perennial grassland—indicating certain "weak" points in development.

Rapidity of germination varied with the different apomicts—one experiment revealing a range of one to seven germinations occurring after four days for seven different apomicts; while for eight other apomicts values ranging from 12 to 81 germinations occurred with an average of somewhere around 50. Similar studies involved light intensity, soil moisture and aeration. Reports of seed longevity indicate a life of from 20–30 years when preserved in the soil. After a four-year burial in clay soil at a depth of 25–30 cm., the most vigorous apomict when tested, germinated four times better than the less viable one. With sexually reproducing weeds, types have not survived which could not retain viability several years in the soil—this cannot be the case with apomicts, however.

Ecological studies involving local distribution emphasized the role of soil moisture, available nutrients, soil pH, and competition

in germination and seedling establishment. The nutritional factor was demonstrated by the abundance of dandelions in grazed and manured pastures, and well-manured roadsides. Where the latter is asphalted and the horses replaced by motor vehicles the dandelions become less abundant in these areas. Studies of pH led the author to conclude that dandelions of this group occur from pH 4.8 to over 7.2, and that certain apomicts thrive better at certain pH levels than do others.

Dandelions compete in alfalfa stands only when stands are sparse, as a result of careless sowing of seed (particularly so in leys), and too intense harvesting and mechanical damage in the autumn. They gain dominance in the ley crop that has been damaged by shocks or hurdles, and in clover that has been killed by nematodes. The light factor here is very important in favoring dandelions, particularly by grazing or heavy cutting. They cannot survive in lush grass because of shading and deeper litter, but also because of the wide-spread grass roots and stolons. Some observations had indicated that the stolons of *Agropyron repens* might yield substances inhibiting the germination and establishment of other plants including dandelions in areas infested by this grass. This controversial subject of the role of toxic excretions in competition, or allelopathy as it has been termed, is not here wholly refuted since the experiments do not take into consideration all aspects of the postulated interactions *in situ* in the natural environment of stolons, and adjacent seeds or seedlings. Granting there was no appreciable effect from spraying dandelions in different stages with undiluted stolon liquid during one summer's experiments, this hypothesis still has not been critically tested.

In the search for pathogenic factors, a fungus was discovered, *Phoma taraxaci* von Hofsten n. sp., which seriously damages this weed. Pathogenicity varied greatly among the more than 450 types isolated. Cultures for use in biological control of this weed were prepared and tested, with little success.

Dandelions are perennial and able to develop reparative shoots from cut or mutilated roots, and thus are favored by shallow tilling. The use of the break plow favors dandelions, and, in many cases, so does the change from horse to tractor plowing. Other tillage deficiencies result in the accumulation of dandelions along headlands and end furrows, along every ridge, tractor plowing with too narrow a headland, around soil-bound stones, and on stubble fields left untouched until autumn plowing. The older observation that cows, but not horses, eat dandelions was verified, and analytical studies of the fodder indicated that well dried dandelion hay can, on the whole, be compared to good clover hay. However, the nutritive value of dandelions after seed spreading hardly amounts to half the value of dandelions in full blossom. Among the three categories of weeds recognized—obligate weeds, facultative weeds, and facultative culture plants, the author concluded that dandelions belong to the latter group.

This is a highly individualistic study and the author is to be commended for expression of personal interpretations and conclusions though they might differ entirely with currently held views. While the author touches upon seedling establishment, this most vital aspect of stand development did not receive the attention possible with regard to seedling root growth, over-wintering factors such as freezing and thawing in relation to root tensile strength and possible breakage, and to other phases of seedling mortality. However, these few omissions do not in any way detract from a highly meritorious examination and report of one of the most universally distributed of weeds.

LAWRENCE J. KING

The Ethnobotany of the Island Caribs of Dominica. W. H. Hodge and Douglas Taylor. Webbia **12**: 513–644. 1957.

This is a catalogue of plants used for food and drink, wood and fiber, medicine and magic, by a handful of primitive people in a back corner of one of the Leeward Islands. Regardless of one's curiosity about such obscure people and remote places, this is a noteworthy paper. For nearly three hundred years after Columbus, Dominica remained an Indian stronghold, the last of all the West Indian Islands to be invaded by Europeans and Negroes. The Dominica Caribs finally lost all but a few square miles of their island and they are losing their racial and cultural integrity. Still they remain the most genuine living example of the Antillean tribes respon-

sible for a key chapter in the spread of agriculture in prehistoric America, so it is important that their plants and plant-lore be recorded.

Hodge and Taylor have done this admirably. Both have long and solid knowledge of the island's people and plants. In addition to the systematic cataloguing of names and uses which is standard in ethnobotany, they make some welcome innovations: a well-written introductory sketch of the history and ethnology of the people, notes on the geography and ecology of the plants, good pictures. Their work is exemplary in another way, the collection of plant specimens permanently preserved for future comparative studies.

JONATHAN SAUER

The Chemistry and Technology of Waxes. Albin H. Warth. ed. 2. 940 pp. 1956. Reinhold Publishing Corp., New York. $18.00.

The much-enlarged second edition of Dr. Albin H. Warth's book will be welcome to those interested in waxes, their kinds, chemistry and uses. Botanists will be interested particularly in the chapter on the waxes from plants—some 170 pages of text—and in the excellent chapter on wax technology and uses in industry.

Perhaps the most unfortunate thing about the book is the relative carelessness taken with the botany of the plants producing waxes. It is surprising that a publishing firm so well known as Reinhold would print a manual of this kind without first checking and editing it carefully. The errors and mistakes are often of the kind that make meaningless the information presented; very often the information is inexact.

In my copy of the book, I have made more than 150 corrections without having read critically all of this chapter. The corrections run the gamut of possibilities: from simple errors such as Bombaceae for Bombacaceae and using the word *order* when *family* is meant (dozens of times); to errors of fact such as putting *Medicago sativa*, buckwheat and flax in the grass family; calling the insect *Gueriniella serratula* a plant; and implying that the chermes of the eastern white pine are plants! In at least two places, the common and scientific names used for a wax-producing plant are not synonymous. Under the heading "Commercial Myrica Waxes" Dr. Warth states that "the name 'Myrtle Wax' has in the past been erroneously given to the Myrica Waxes", while on the foregoing page he discussed them as Myrtle Waxes! A paragraph entitled "Olive-Bark Wax" contains a discussion of the tropical almond and mentions "Olive-tree leaves". *Simmondsia chinensis* is described as a "wooden evergreen shrub". Editorial carelessness is exemplified by "Genetically the word *Pedilanthus* is from the Greek meaning 'sandal flower,' . . .". There is a paragraph heading "Oriental longleaf plant foliage waxes" under which only plants with short leaves are mentioned.

In the index all the scientific names of plants are brought together under "Plants, waxes from" rather than in their usual place scattered alphabetically through the index.

Bibliographic references, 332 for the natural waxes, are abundant. Titles of articles are not given.

LOUIS O. WILLIAMS

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Abbreviations. **A.** = abstract; **Art.** = article; **B.R.** = book review.

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